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Shiraki

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(54) **ETHERNET SWITCH AND
COMMUNICATION METHOD**

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H04L 12/741 (2013.01)
H04L 12/931 (2013.01)

(52) **U.S. Cl.**
CPC **H04L 45/74** (2013.01); **H04L 49/357**
(2013.01)

(58) **Field of Classification Search**
None
See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

2004/0213272 A1 10/2004 Nishi et al.
2008/0175265 A1* 7/2008 Yonge H04B 3/54
370/447

2009/0037977 A1* 2/2009 Gai H04L 41/00
726/1
2009/0276526 A1* 11/2009 Carlson H04L 63/101
709/225
2011/0078334 A1 3/2011 Arakawa et al.
2011/0135303 A1 6/2011 Hufferd
2012/0106957 A1* 5/2012 Willeke H04L 29/12207
398/58
2012/0177041 A1 7/2012 Berman

FOREIGN PATENT DOCUMENTS

JP 2004-304371 A 10/2004
JP 2008-258917 10/2008
JP 2011-076582 4/2011

OTHER PUBLICATIONS

Japanese Office Action mailed on Jan. 26, 2016 for corresponding
Japanese Patent Application No. 2012-195108, with Partial English
Translation, 5 pages.

* cited by examiner

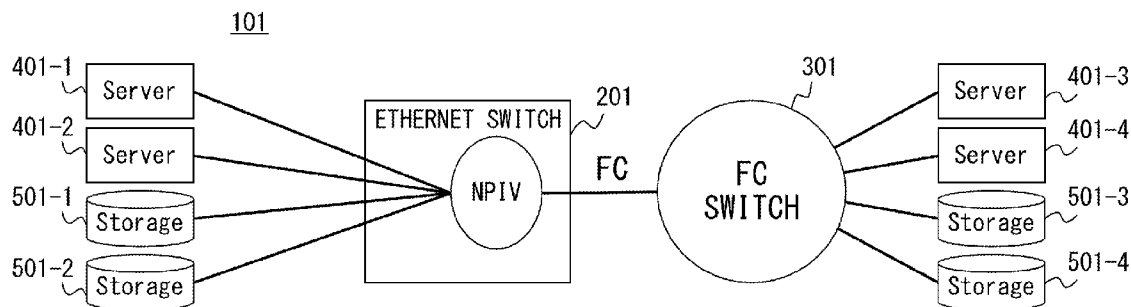
Primary Examiner — Kevin C Harper

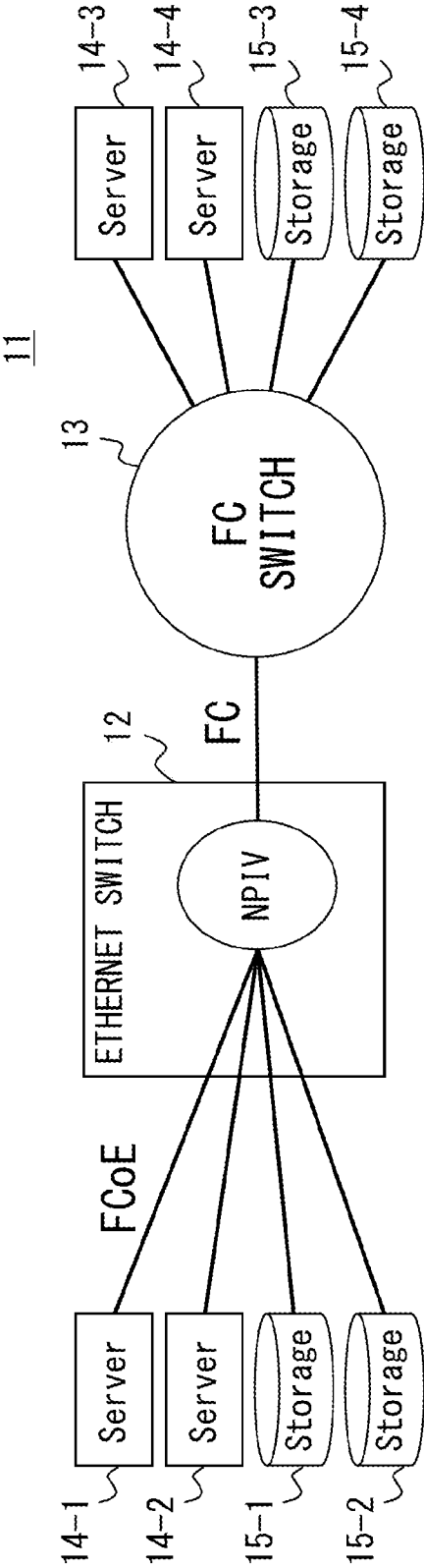
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(57) **ABSTRACT**

An Ethernet switch which is connected to a plurality of
external devices using an encapsulating I/O protocol over
Ethernet, and is connected to a I/O protocol switch using
N_Port ID virtualization includes: a storage unit which
stores destination information describing an external device
whose connection is established in the FCoE in the plurality
of external devices; and a processor. When the processor
receives a packet addressed from a first external device to a
second external device in the external devices, the processor
checks whether or not the destination information describes
the second external device. When the second external device
is described in the destination information, the processor
transmits the packet to the second external device.

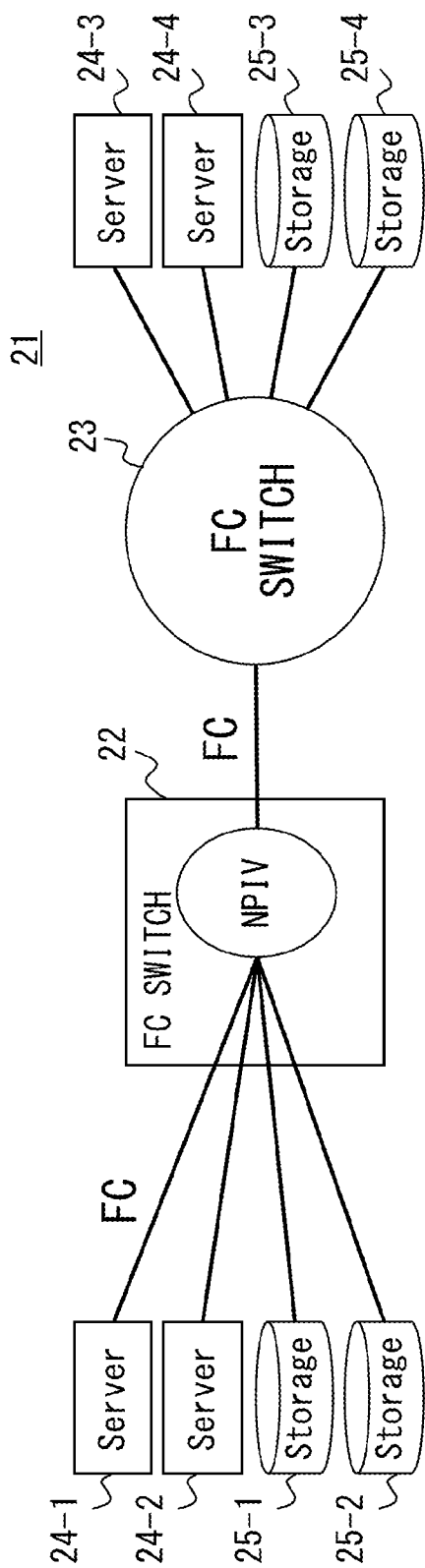
10 Claims, 23 Drawing Sheets





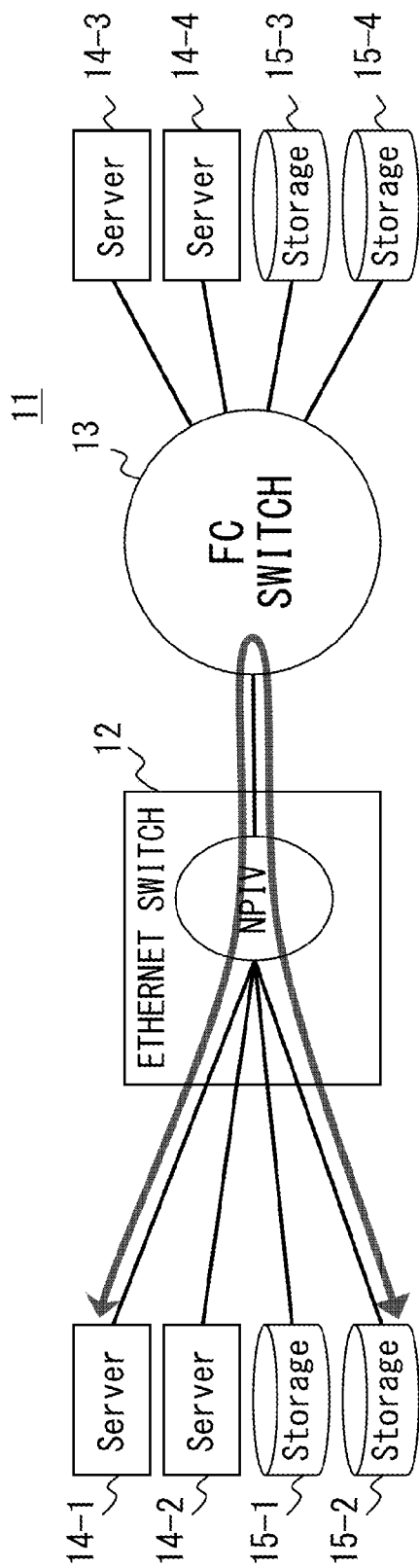
RELATED ART

FIG. 1A



RELATED ART

FIG. 1B



RELATED ART

FIG. 2

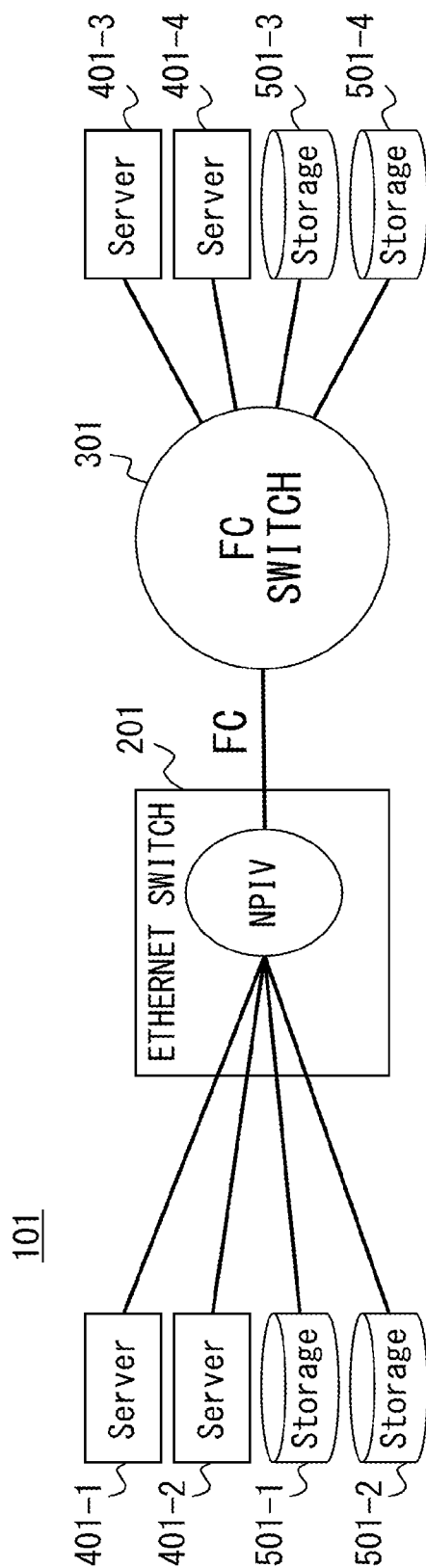


FIG. 3

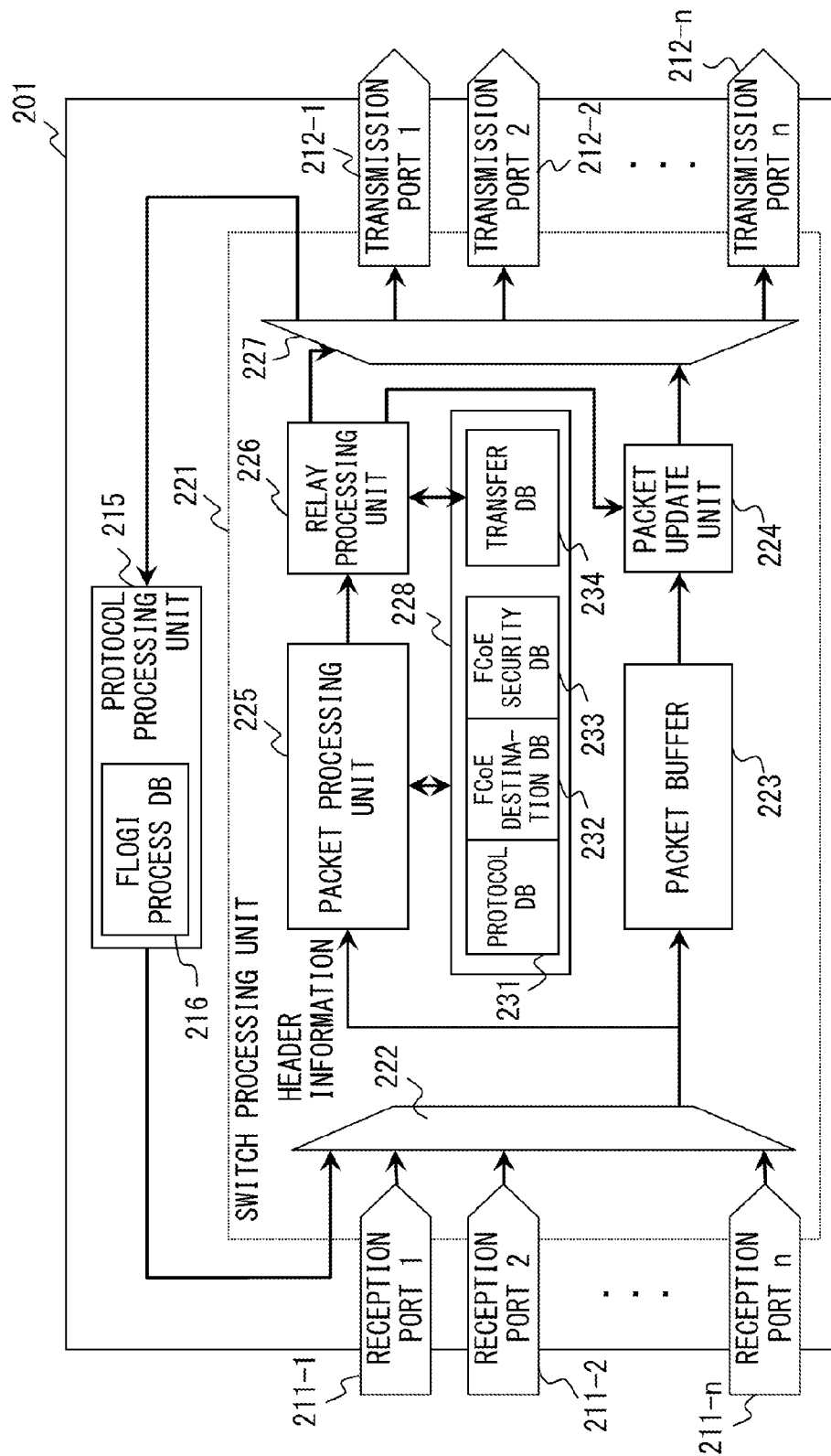


FIG. 4

216

RECEPTION PORT	TRANSMISSION PORT	PRE-TRANSFORM PACKET HEADER INFORMATION (INCLUDING SOURCE MAC ADDRESS, FC EXCHANGE ID)	POST-TRANSFORM PACKET HEADER INFORMATION (INCLUDING FC EXCHANGE ID)
...	...	...	...
...	...	...	...

FIG. 5

232

FC_ID	MAC ADDRESS	PORT NUMBER
...	...	...
...	...	...

FIG. 6

FC_ID (1)	FC_ID (2)
...	...
...	...

233

FIG. 7

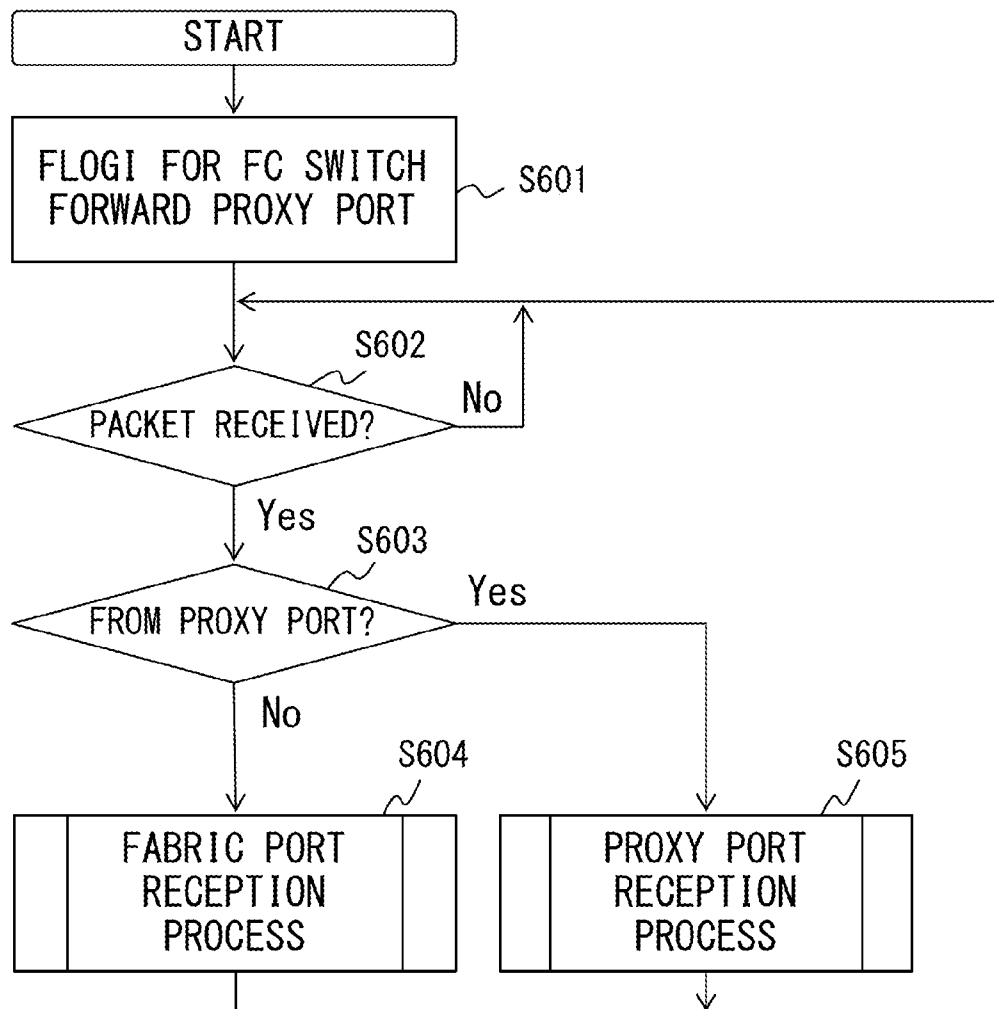


FIG. 8

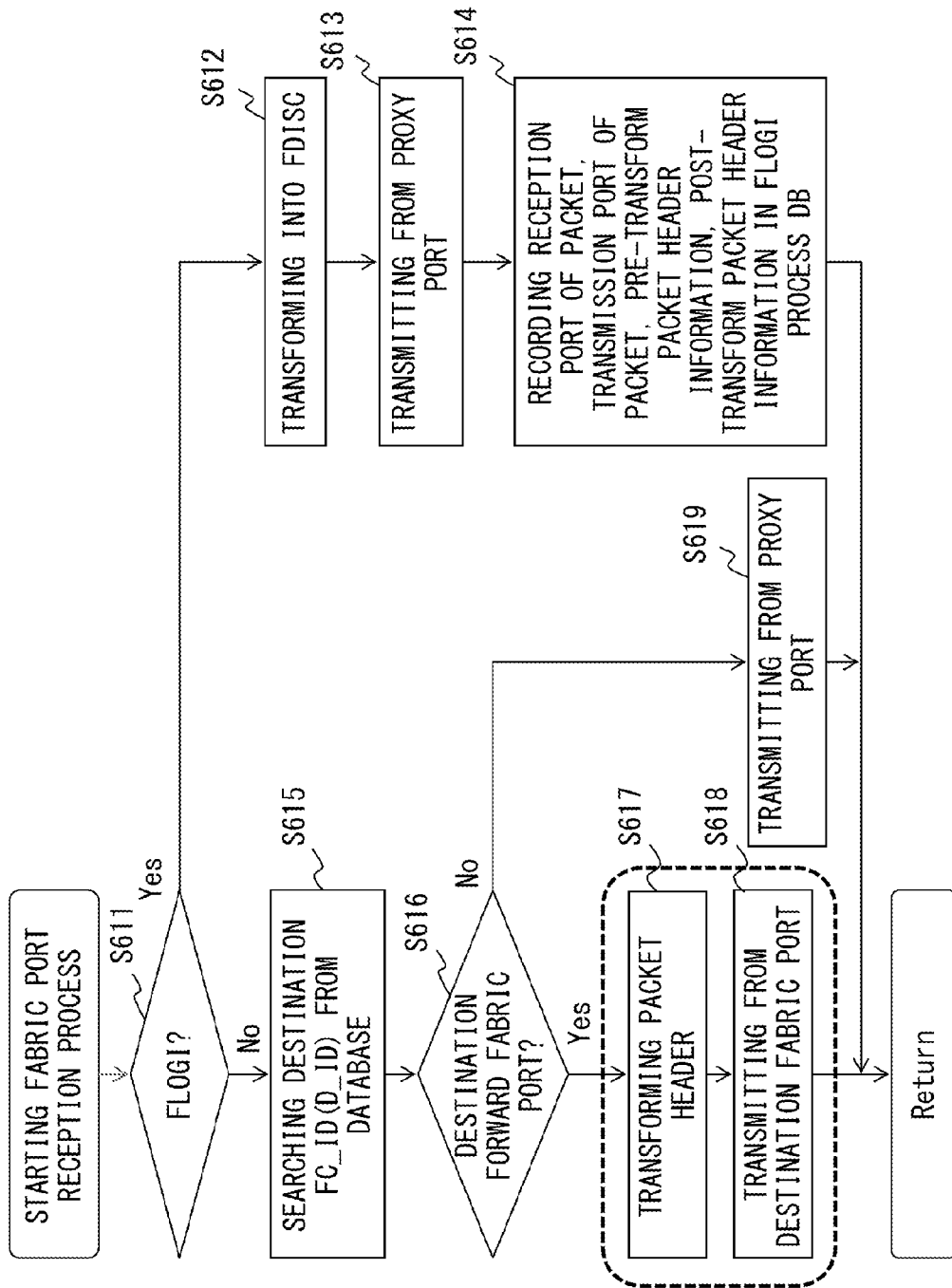


FIG. 9

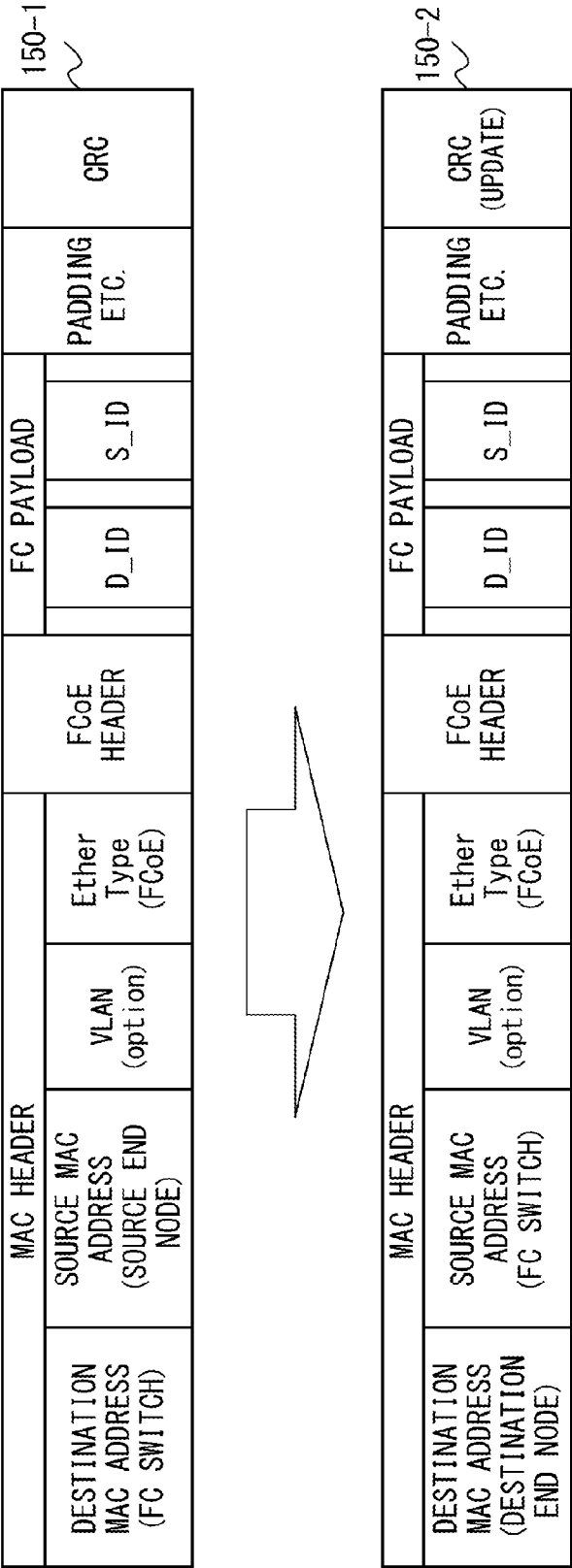


FIG. 10

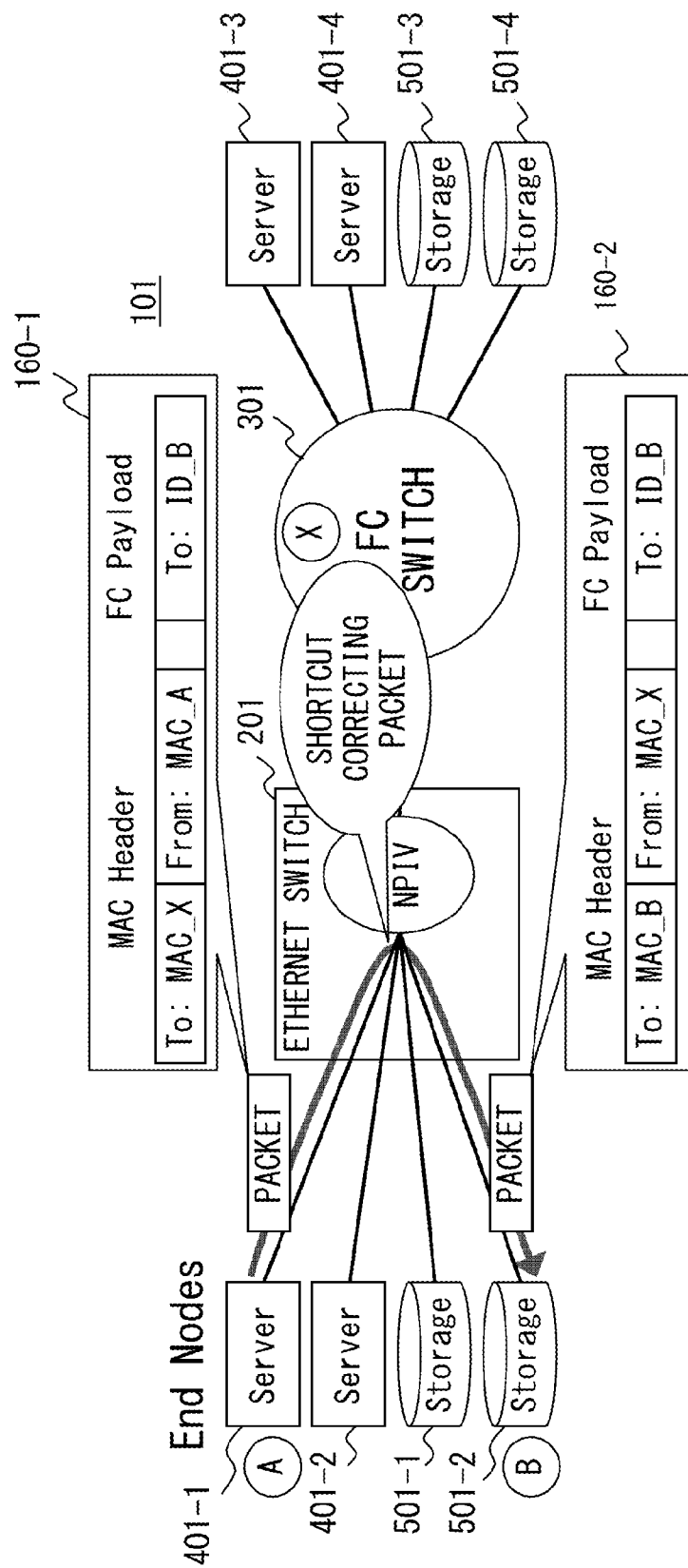


FIG. 11

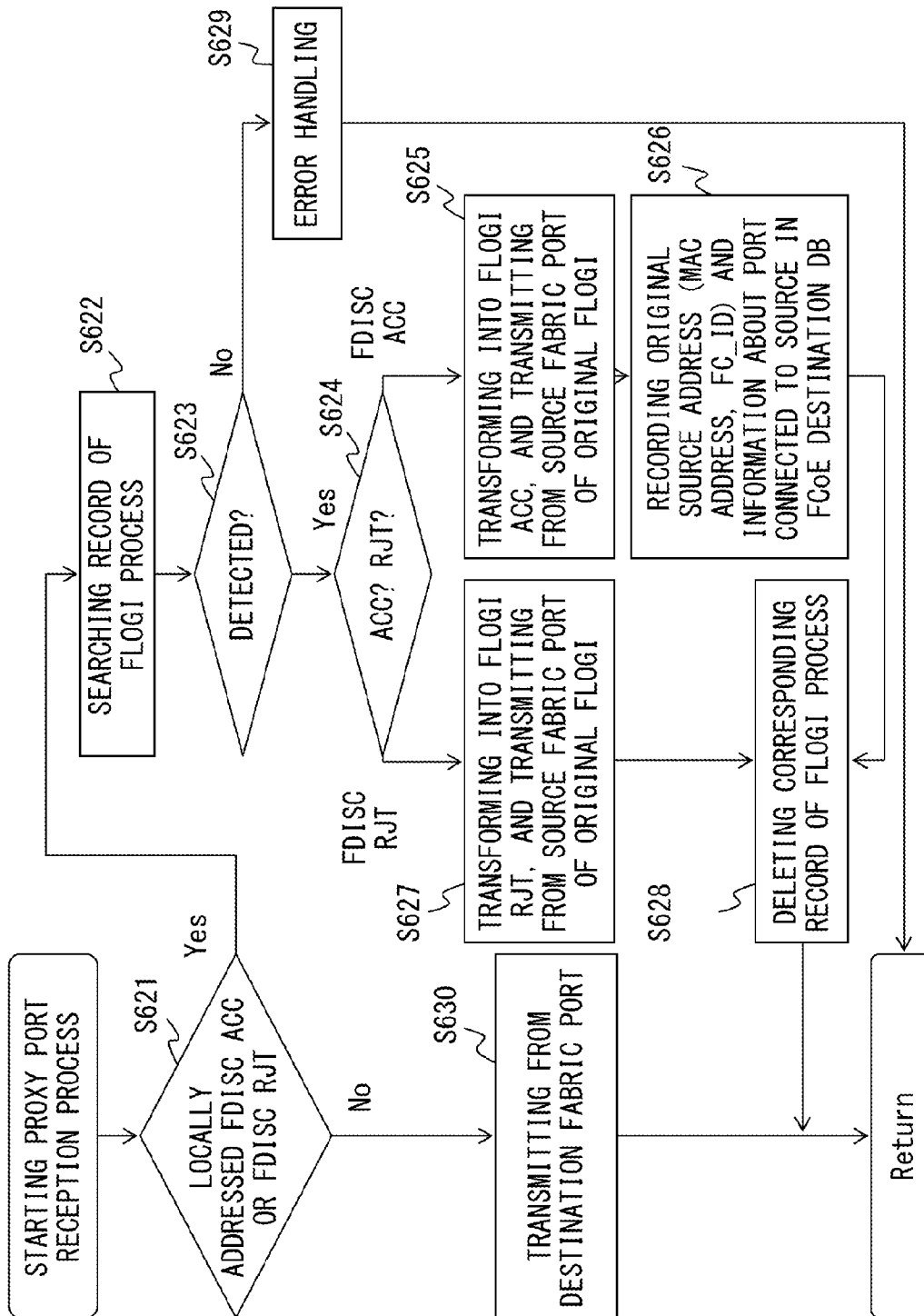


FIG. 12

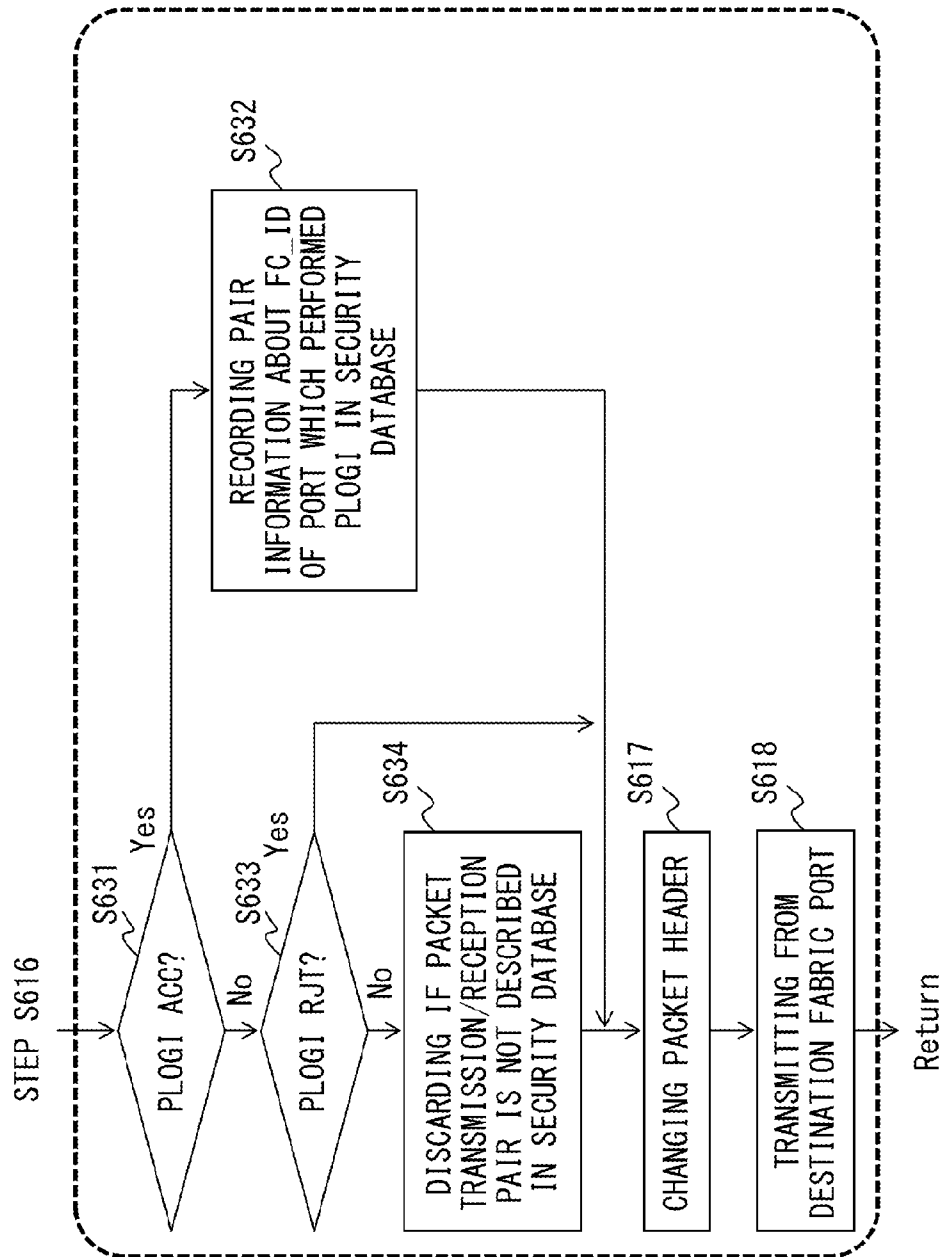


FIG. 13

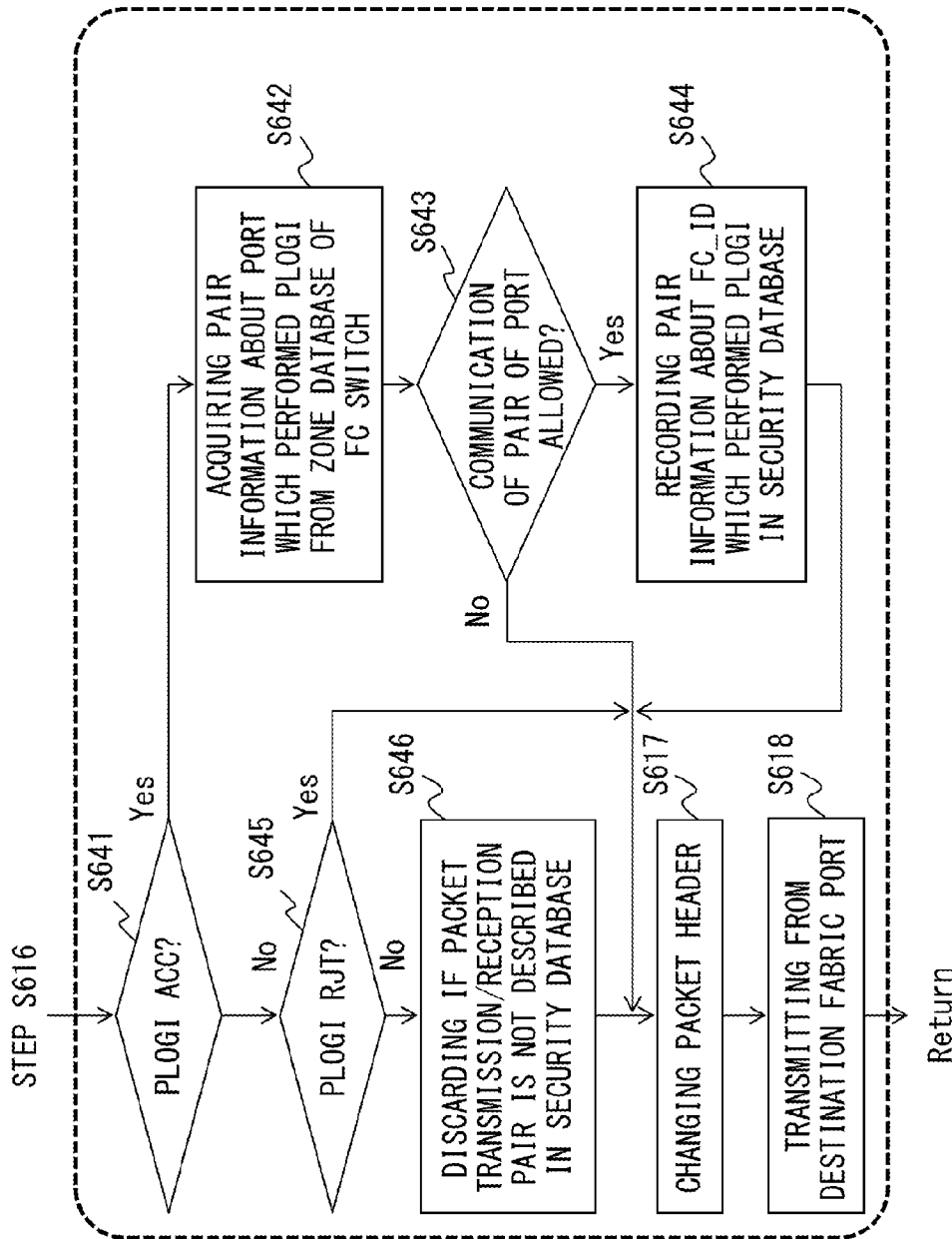


FIG. 14

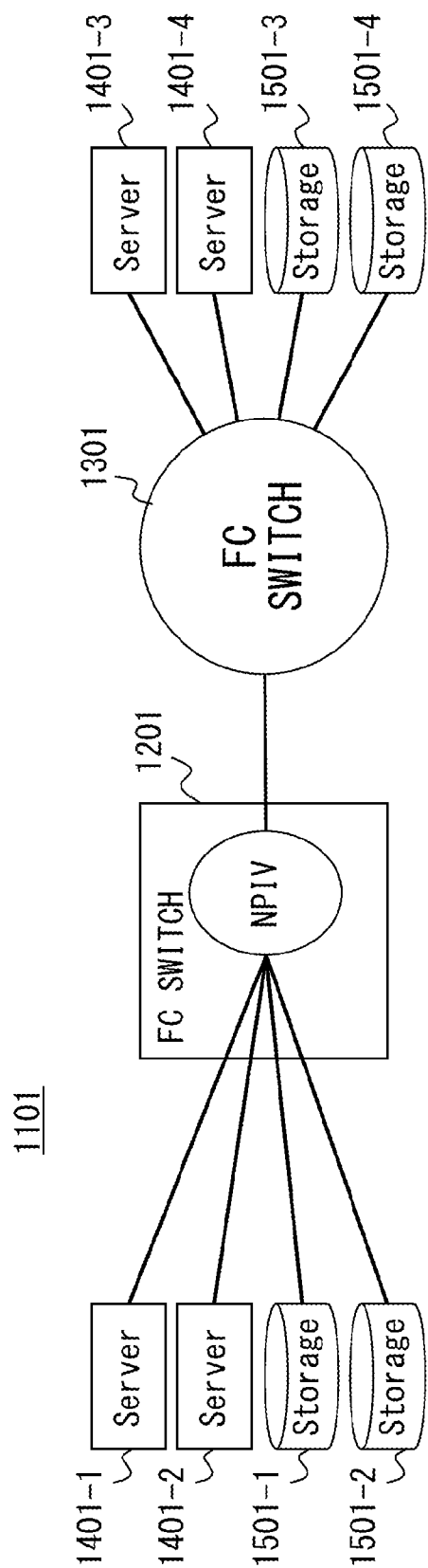


FIG. 15

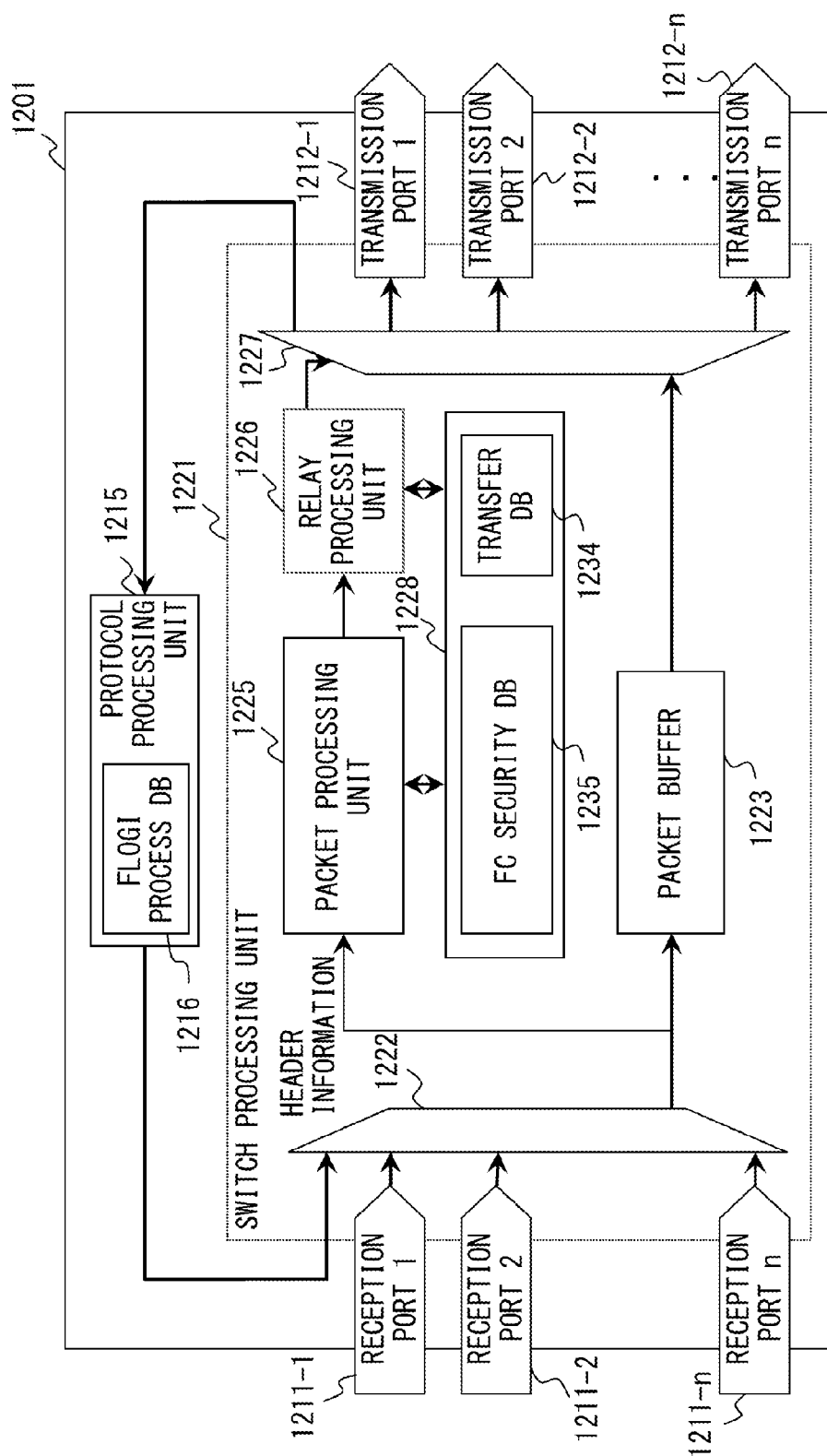


FIG. 16

1216

RECEPTION PORT	TRANSMISSION PORT	PRE-TRANSFORM PACKET HEADER INFORMATION (INCLUDING FC EXCHANGE ID)	POST-TRANSFORM PACKET HEADER INFORMATION (INCLUDING FC EXCHANGE ID)
...	...	...	...
...	...	...	...

FIG. 17

1234

FC_ID	PORT NUMBER
...	...
...	...

FIG. 18

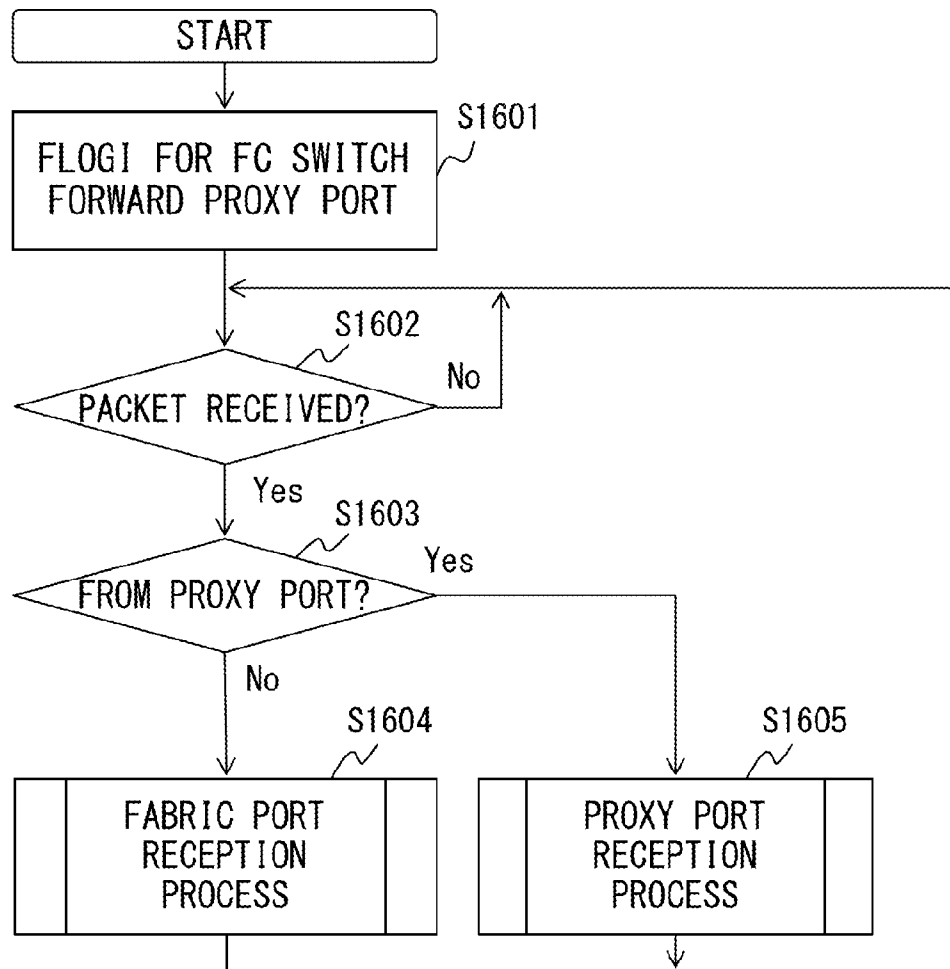


FIG. 19

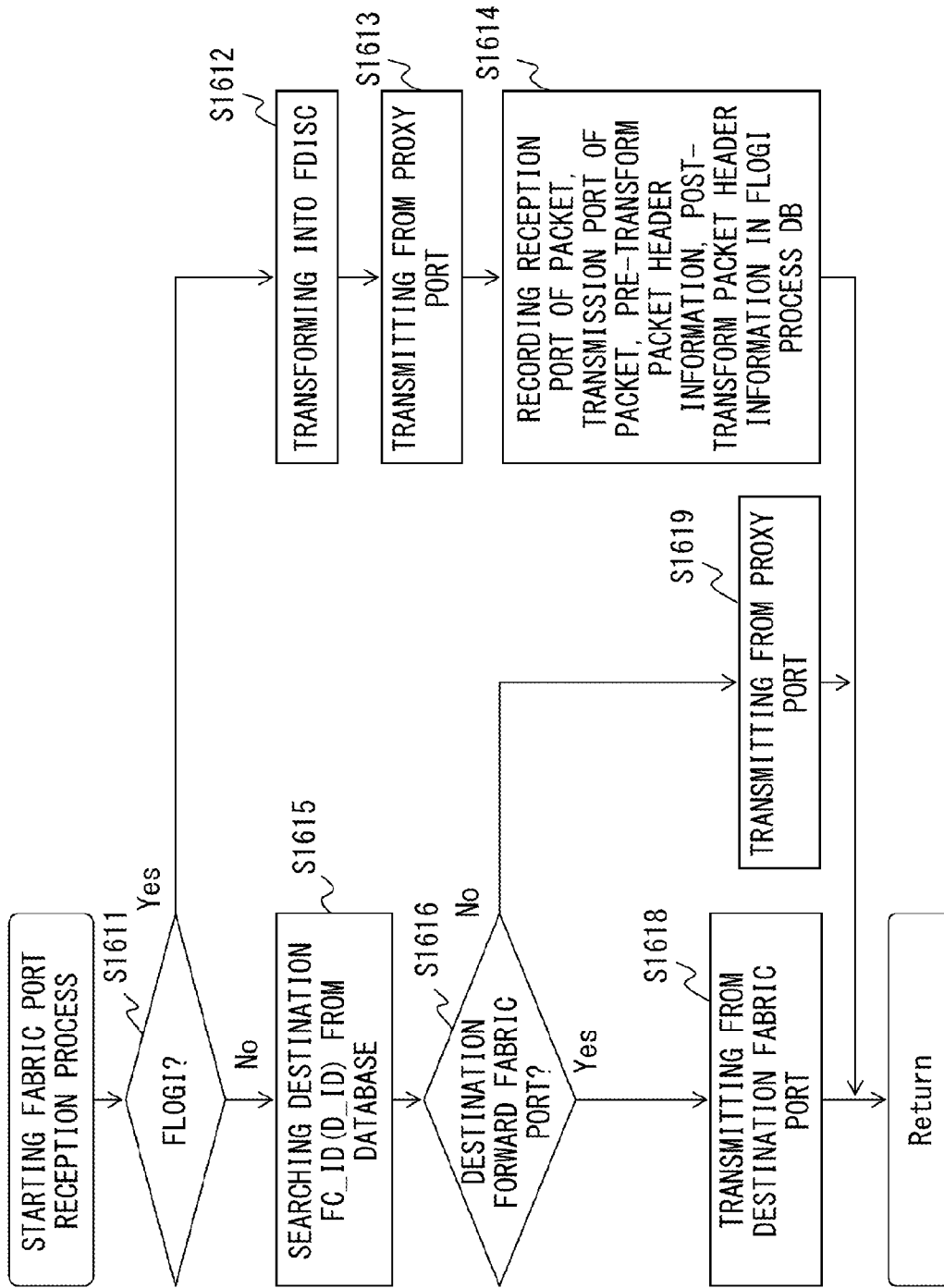


FIG. 20

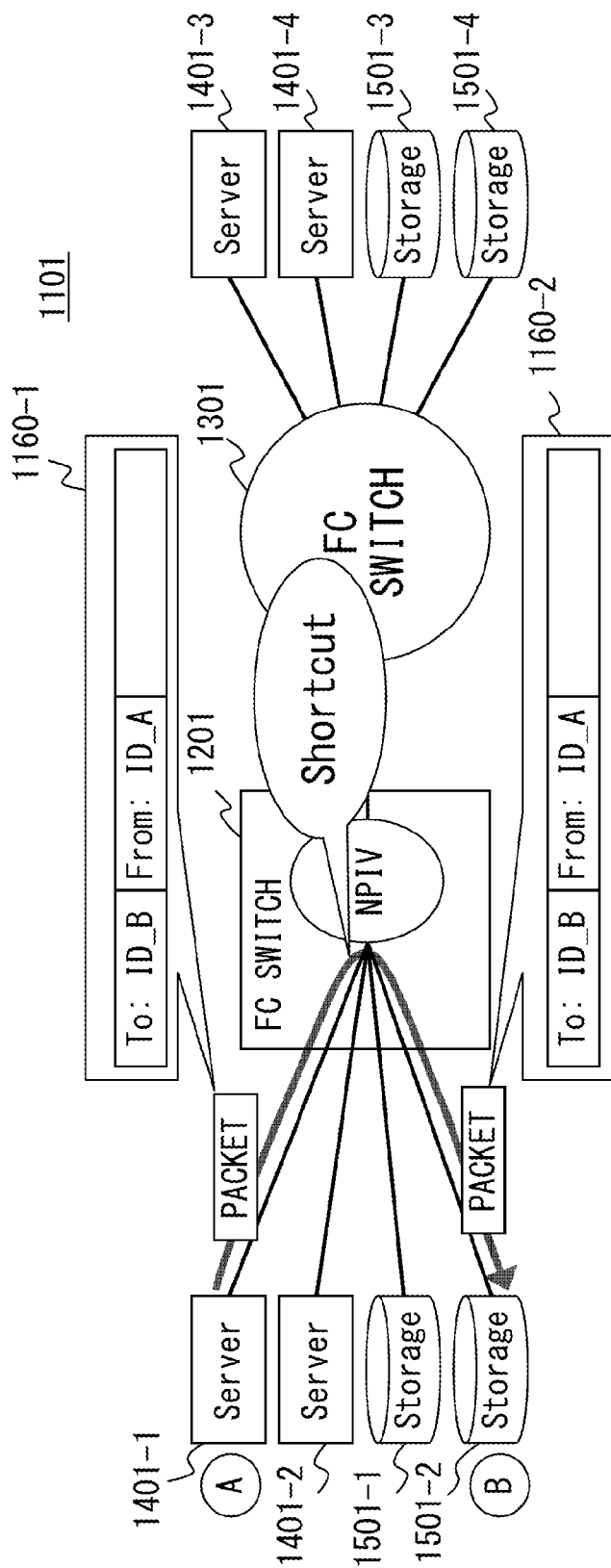


FIG. 21

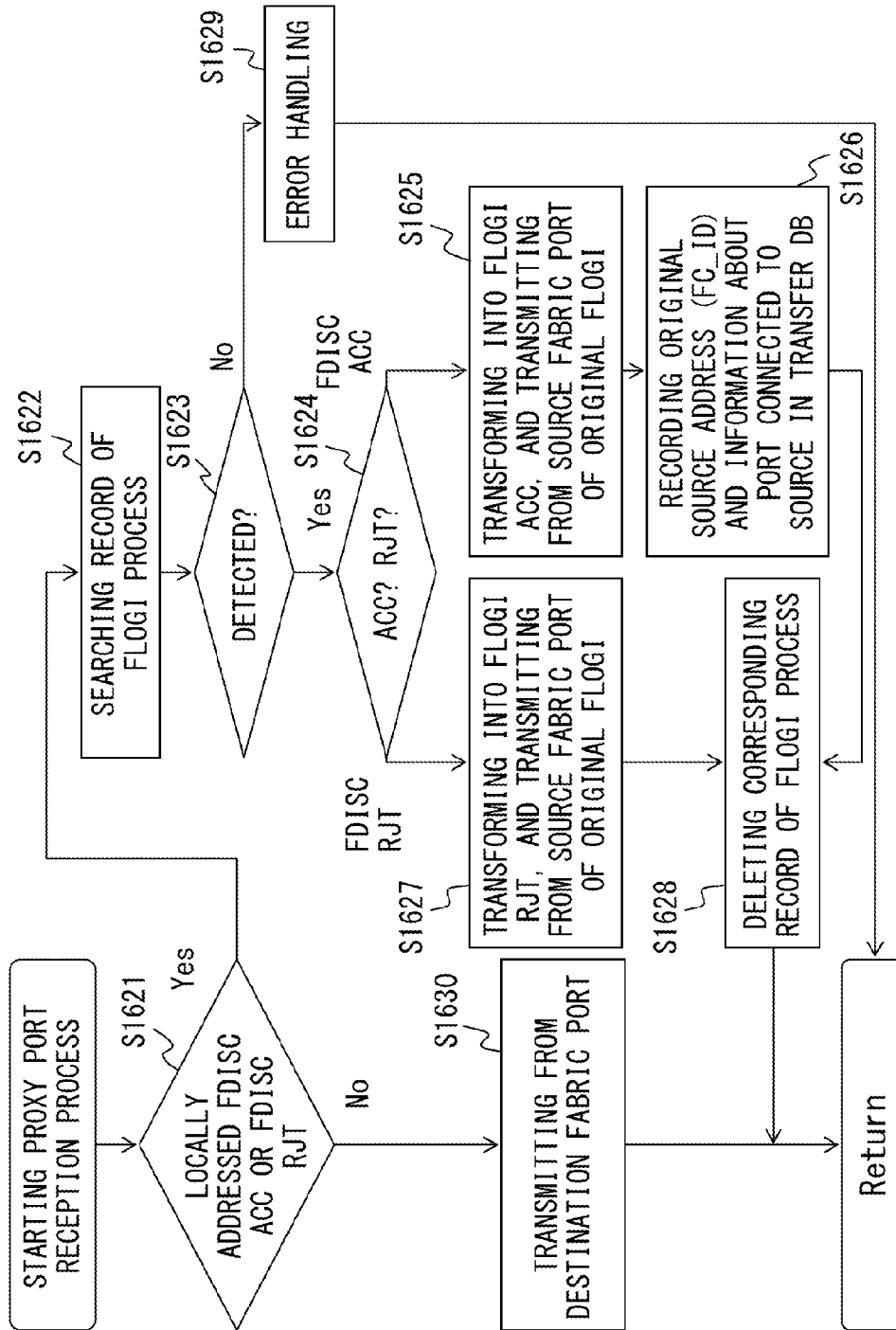


FIG. 22

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ETHERNET SWITCH AND
COMMUNICATION METHODCROSS-REFERENCE TO RELATED
APPLICATIONS

This application is based upon and claims the benefit of priority of the prior Japanese Patent Application No. 2012-195108, filed on Sep. 5, 2012, the entire contents of which are incorporated herein by reference.

FIELD

The embodiments discussed herein are related to an Ethernet switch and communication method.

BACKGROUND

Since a storage communication requires higher communication performance than an inter-server communication, a different network has conventionally been provided for each of the communications. The inter-server communication network is called a local area network (LAN), and the storage communication network is called a storage area network (SAN).

However, with the recent progress of high-speed Ethernet, an integrated network has been realized by integrating the inter-server communication with the storage communication. A Fibre Channel over Ethernet (FCoE) is the technology with the Ethernet for processing a packet of a Fibre Channel (FC).

A conventional FC device may be accessed from a system using the FCoE through an appropriate gateway device. It is a method for configuring a new integrated network system while utilizing existing resources.

FIG. 1A illustrates a configuration of a conventional system.

A system 11 includes an Ethernet switch 12, an FC switch 13, a server 14-*i* (*i*=1~4), and storage 15-*i*.

The Ethernet switch 12 performs processes such as routing and transforming a packet, etc.

The Ethernet switch 12 has a gateway using N_port ID virtualization (NPIV), and is connected to the FC switch 13 using the NPIV.

The NPIV refers to the technology of virtualizing the ID of an N_Port and allows a physical port (N_Port) to have a plurality of port names and fabric addresses (N_Port ID).

A plurality of devices (servers 14-1 and 14-2, storage 15-1 and 15-2) are connected to the Ethernet switch 12, and the Ethernet switch 12 presents the FC switch 13 with a plurality of devices as if they were one device using the NPIV.

The Ethernet switch 12 is connected to the FC switch 13, servers 14-1 and 14-2, and the storage 15-1 and 15-2 through a network such as a LAN etc.

The port to which the FC switch 13 of the Ethernet switch 12 has the function of transform the FCoE and the FC. The function assigns a unique MAC address to the FC switch 13, removes the capsule of the FCoE from the FCoE packet transmitted outside from the port, and transmits an FC packet. The function capsules the FC packet received from the port into an FCoE packet.

The FC switch 13 is connected to the Ethernet switch 12, the servers 14-3 and 14-4, and the storage 15-3 and 15-4.

An FC-SAN is configured by the FC switch 13, the servers 14-3 and 14-4, and the storage 15-3 and 15-4.

In the system 11 in FIG. 1A, the FCoE network is connected to the SAN.

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There also is a system in which SANs are connected.

FIG. 1B illustrates a configuration of another conventional system.

A system 21 includes an FC switch 22, an FC switch 23, a server 24-*i* (*i*=1~4), and storage 25-*i*.

The FC switch 22 performs processes of routing and transforming a packet, etc.

The FC switch 22 has a gateway using an NPIV, and is connected to the FC switch 23 using the NPIV.

A plurality of units (servers 24-1 and 24-2, storage 25-1 and 25-2) are connected to the FC switch 22, and the FC switch 22 presents the FC switch 23 with a plurality of devices as if they were one device using the NPIV.

The FC switch 22 is connected to the FC switch 23, the servers 24-1 and 24-2, and the storage 25-1 and 25-2.

The FC switch 23 is connected to the FC switch 22, the servers 24-3 and 24-4, and the storage 25-3 and 25-4.

An FC-SAN is configured by the FC switch 23, the servers 24-3 and 24-4, and the storage 25-3 and 25-4.

The route of a packet when the packet is transmitted between the FCoE devices in the system in FIG. 1A is described below.

FIG. 2 illustrates a communication between conventional FCoE devices.

FIG. 2 illustrates a communication between the server 14-1 and the storage 15-2.

When a packet is transmitted from the server 14-1 to the storage 15-2, the packet is transmitted from the server 14-1 to the Ethernet switch 12, transferred from the Ethernet switch 12 to the FC switch 13, transmitted from the FC switch 13 to the Ethernet switch 12, and transmitted from the Ethernet switch 12 to the storage 15-2.

Thus, in the communication between the devices under the NPIV connected to the Ethernet switch 12, a packet is transmitted through the FC switch 13.

In the conventional system, although a communication is performed between the devices under the NPIV, the packet is transmitted through an external switch. Therefore, the path is long and the communication latency becomes large. Furthermore, there is a communication bottleneck between switches.

[Patent Document 1] Japanese Laid-open Patent Publication No. 2011-76582

[Patent Document 2] Japanese Laid-open Patent Publication No. 2008-258917

SUMMARY

According to an aspect of the invention, an Ethernet switch is connected to a plurality of external devices using an encapsulating I/O protocol over Ethernet, and is connected to an I/O protocol switch using an N_Port ID virtualization.

The Ethernet switch includes a storage unit and a processor.

The storage unit stores destination information describing an external device whose connection is established in the encapsulating I/O protocol over Ethernet in the plurality of external devices.

When the processor receives a packet address from a first embodiment to a second embodiment in the plurality of external devices, the processor checks whether or not the second embodiment is described in the destination information, and transmits the packet to the second embodiment if the second embodiment is described in the destination information.

The object and advantages of the invention will be realized and attained by means of the elements and combinations particularly pointed out in the claims.

It is to be understood that both the foregoing general description and the following detailed description are exemplary and explanatory and are not restrictive of the invention, as claimed.

DESCRIPTION OF EMBODIMENTS

FIG. 1A illustrates a configuration of a conventional system;

FIG. 1B illustrates a configuration of another conventional system;

FIG. 2 illustrates a communication between conventional FCoE devices;

FIG. 3 illustrates a configuration of the system according to the first embodiment;

FIG. 4 illustrates a configuration of the Ethernet switch according to the first embodiment;

FIG. 5 is an example of a FLOGI process DB;

FIG. 6 is an example of an FCoE destination DB;

FIG. 7 is an example of an FCoE security DB;

FIG. 8 is a flowchart of packet processing of an Ethernet switch according to the first embodiment;

FIG. 9 is a detailed flowchart of a Fabric port reception process according to the first embodiment;

FIG. 10 illustrates a packet before and after the change according to the first embodiment;

FIG. 11 illustrates the communication between the FCoE devices according to the first embodiment;

FIG. 12 is a detailed flowchart of the Proxy port reception process according to the first embodiment;

FIG. 13 is a flowchart of the first security check process according to the first embodiment;

FIG. 14 is a flowchart of the second security check process according to the first embodiment;

FIG. 15 illustrates a configuration of the system according to a second embodiment;

FIG. 16 illustrates a configuration of the FC switch according to the second embodiment;

FIG. 17 is an example of the FLOGI process DB;

FIG. 18 is an example of a transfer DB;

FIG. 19 is a flowchart of packet processing of the FC switch according to the second embodiment;

FIG. 20 is a detailed flowchart of the Fabric port reception process according to the second embodiment;

FIG. 21 illustrates a communication between FC devices according to the second embodiment; and

FIG. 22 is a detailed flowchart of the Proxy port reception process according to the second embodiment.

DESCRIPTION OF EMBODIMENTS

The embodiments of the present invention are described below with reference to the attached drawings.

First Embodiment

FIG. 3 illustrates a configuration of the system according to the first embodiment.

A system 101 includes an Ethernet switch 201, an FC switch 301, a server 401-*i* (*i*=1~4), and storage 501-*i*.

The Ethernet switch 201 performs processes of routing and transforming a packet etc.

The Ethernet switch 201 has a gateway using N_Port ID virtualization (NPIV), and is connected to the FC switch 301 using the NPIV.

The NPIV refers to the technology of virtualizing the ID of an N_Port to allow one physical port (N_Port) to have a plurality of port names and fabric addresses (N_Port ID).

The Ethernet switch 201 presents the FC switch 301 with a plurality of devices using the NPIV as if they were one device.

The Ethernet switch 201 is connected to the FC switch 301, servers 401-1 and 401-2, and storage 501-1 and 501-2.

The port to which the FC switch 301 of the Ethernet switch 201 has the function of mutually transforming the FCoE and the FC. The function assigns a unique MAC address to the FC switch 301, removes a capsule of the FCoE from the FCoE packet transmitted outside the port, and transmits an FC packet. The function capsulate the FC packet received from the port to an FCoE packet. In this case, a MAC address assigned as a transmission MAC address to the FC switch 301 is used.

The Ethernet switch 201 is connected to the servers 401-1 and 401-2 and the storage 501-1 and 501-2 through a network such as a LAN etc.

The FC switch 301 is connected to the Ethernet switch 201, the servers 401-3 and 401-4, and the storage 501-3 and 501-4.

The FC switch 301 is connected to the Ethernet switch 201, the servers 401-3 and 401-4, and the storage 501-3 and 501-4 through an optical fiber cable, and communicates with the Ethernet switch 201, the servers 401-3 and 401-4, and the storage 501-3 and 501-4 using the FC.

The FC-SAN is configured by the FC switch 301, the servers 401-3 and 401-4, and the storage 501-3 and 501-4.

The server 401 is an information processing device which performs various types of processing.

The servers 401-1 and 401-2 communicate with the Ethernet switch 201 using the FCoE. The servers 401-1 and 401-2 have a port for use in connection to the Ethernet switch 201, and each port has a unique MAC address. In addition, a unique Fibre Channel ID is assigned to each port.

The servers 401-3 and 401-4 has an FC interface, and communicate with the FC switch 301 using the FC.

The storage 501 is a device which stores data. The storage 501 is, for example, a disk array device having a plurality of hard disk drives.

The storage 501-1 and 501-2 communicate with the Ethernet switch 201 using the FCoE. The storage 501-1 and 501-2 has a port for use in connection with the Ethernet switch 201, and each port has a unique MAC address. A unique Fibre Channel ID is assigned to each port.

The storage 501-3 and 501-4 has an FC interface, and communicate with the FC switch 301 using the FC.

The servers 401-1 and 401-2 and the storage 501-1 and 501-2 have the function of mutually transforming the FCoE and the FC, transform an FC packet into an FCoE packet, and transmits the transformed packet to the Ethernet switch 201. The servers 401-1 and 401-2 and the servers 401-1 and 401-2 are examples of an FCoE device.

FIG. 4 illustrates a configuration of the Ethernet switch according to the first embodiment.

The Ethernet switch 201 includes a reception port 211-*j* (*j*=1~*n* (*n* is an integer)), a transmission port 212-*j*, a protocol processing unit 215, and a switch processing unit 221.

The reception port 211 is connected to the FC switch 301, the servers 401-1 and 401-2, or the storage 501-1 and 501-2, and is a port which receives a packet.

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The transmission port **212** is connected to the FC switch **301**, the servers **401-1** and **401-2**, or the storage **501-1** and **501-2**, and is a port which transmits a packet.

The reception port **211-j** and the transmission port **212-j** configure a set of ports, and the same port number is assigned to the reception port **211-j** and the transmission port **212-j**.

In the present embodiment, the reception port **211** and the transmission port **212** which is connected to the FC switch **301** is called a Proxy port.

the reception port **211** and the transmission port **212** which is connected to the servers **401-1** and **401-2** or the storage **501-1** and **501-2** is called a Fabric port.

The protocol processing unit **215** perform the processes of establishing a connection, monitoring a protocol, issuing an instruction to the switch processing unit **221**, etc.

The protocol processing unit **215** has a FLOGI process database (DB) **216**.

The protocol processing unit **215** is realized by, for example, the central processing unit (CPU) (not illustrated in the attached drawings) reading and executing the software stored in the memory (not illustrated in the attached drawings) in the Ethernet switch **201**. The protocol processing unit **215** may be realized by, for example, a hardware circuit, a processor, etc.

The FLOGI process DB **216** is a record of processing of the FLOGI which is one of the protocols for establishing a connection in the FCoE (FCoE initialization protocol (FIP)) executed by the Ethernet switch **201**.

FIG. **5** is an example of the FLOGI process DB.

The FLOGI process DB **216** has items of a reception port, a transmission port, a pre-transform packet header information, and a post-transform packet header information. The reception port, the transmission port, the pre-transform packet header information, and the post-transform packet header information are associated with one another and stored in the FLOGI process DB **216**.

The reception port is an identifier indicating the port which has received a packet. The reception port stores, for example, a port number of the reception port **211** which has received a packet.

The transmission port is an identifier indicating a port which has transmitted a packet. The transmission port stores, for example, a port number of the transmission port **212** which has transmitted a packet.

The pre-transform packet header information is the information about the header of a packet before a transform (FLOGI). The pre-transform packet header information includes a source MAC address and an FC exchange ID.

The source MAC address is a MAC address of the port which has transmitted the packet of the FLOGI.

The FC exchange ID is the identification information assigned to each of the related packets. For example, the FLOGI and the FLOGI ACCEPT (ACC) as a corresponding reply have the same FC exchange ID.

The post-transform packet header information is the information about the header of a packet after a transform (FDISC). The post-transform packet header information includes an FC exchange ID.

The switch processing unit **221** includes a multiplexer **222**, a packet buffer **223**, a packet update unit **224**, a packet processing unit **225**, a relay processing unit **226**, a demultiplexer **227**, and a storage unit **228**.

The switch processing unit **221** is realized by, for example, a hardware circuit, a processor, etc.

The multiplexer **222** outputs a packet input from the protocol processing unit **215** and the reception port **211** to

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the packet buffer **223**. Header information is extracted by a header information extraction unit (not illustrated in the attached drawings) from a packet output from the multiplexer **222**, and input to the packet processing unit **225**.

The packet buffer **223** is a buffer which temporarily stores a received packet. The packet buffer **223** outputs the stored packet to the packet update unit **224**.

The packet update unit **224** changes the header of the packet based on an instruction from the relay processing unit **226**.

The packet processing unit **225** determines the process of the packet based on the header information, a protocol database (DB) **231**, an FCoE destination DB **232**, and an FCoE security DB **233**. The packet processing unit **225** performs a write and a read about the protocol DB **231**, the FCoE destination DB **232**, and the FCoE security DB **233**. The packet processing unit **225** outputs a control signal indicating the destination of a packet and the change a header to the relay processing unit **226**.

The relay processing unit **226** outputs a control signal indicating the destination of the packet to the demultiplexer **227** based on the output from the packet processing unit **225** or a transfer DB **234**. The relay processing unit **226** also instructs the packet update unit **224** to change the header of the packet based on the control signal from the packet processing unit **225**.

The demultiplexer **227** outputs the packet to one of the transmission port **212** and the protocol processing unit **215** according to the control signal from the relay processing unit **226**.

The storage unit **228** is a device which stores data. The storage unit **228** is, for example, RAM (random access memory). The storage unit **228** stores the FCoE destination DB **232**, the FCoE security DB **233**, and the transfer DB **234**.

The protocol DB **231** stores the information for identification of the type of packet. The packet processing unit **225** may discriminate the type of packet by comparing the input header information with the protocol DB **231**.

The FCoE destination DB **232** is the information about the FCoE device connected to the Ethernet switch **201** and the information about the transmission port **212** connected to the FCoE device.

FIG. **6** is an example of the FCoE destination DB.

The FCoE destination DB **232** includes items of an FC ID, a MAC address, and a port number. The FCoE destination DB **232** associates and describes the FC ID, the MAC address, and the port number.

The FC ID is an identifier assigned to each port of the device connected to the Ethernet switch **201**.

The MAC address is assigned to the port of an FCoE device.

The port number indicates the transmission port **212**.

With reference to the FCoE destination DB, it is judged the port of which device (server or storage) a port of the Ethernet switch **201** is connected to.

The FCoE security DB **233** indicates the set of the ports whose connection has been established.

FIG. **7** is an example of the FCoE security DB.

The FC ID of each port of a set of ports whose connection is established is associated and stored in the FCoE security DB **233**.

The transfer DB **234** is the information about the port to which a packet is output. The destination MAC address is associated with a port number and stored in the transfer DB **234**.

FIG. 8 is a flowchart of the packet processing of the Ethernet switch according to the first embodiment.

In step S601, the protocol processing unit 215 performs fabric login (FLOGI) to the FC switch 301 through the switch processing unit 221. In the NPIV, the subsequent login processing is performed by issuing a fabric discovery (FDISC) command for the connection established by the FLOGI, thereby establishing a plurality of connections on one link. The FLOGI processing in step S601 is the base of the subsequent login processing.

In step S602, the switch processing unit 221 waits for the reception of a packet, and when it receives the packet, control is passed to step S603.

In step S603, the protocol processing unit 215 and the switch processing unit 221 judge whether or not the received packet has been received in the Proxy port. If the received packet has been received in the Proxy port (that is, if it has been received from the FC switch 301), control is passed to step S605. If the received packet has not been received in the Proxy port (that is, if it has been received from any of the servers 401-1, 401-2 or the storage 501-1, 501-2), then control is passed to step S604. The Ethernet switch 201 has the information indicating that each port of the reception port 211 and the transmission port 212 is the Proxy port or the Fabric port, and the protocol processing unit 215 and the switch processing unit 221 may judge according to the information whether the reception port 211 which has received the packet is the Proxy port or the Fabric port.

In step S604, the Ethernet switch 201 performs the Fabric port reception process. The Fabric port reception process is described later in detail.

In step S605, the Ethernet switch 201 performs the Proxy port reception process. The Proxy port reception process is described later in detail.

FIG. 9 is a detailed flowchart of the Fabric port reception process according to the first embodiment.

FIG. 9 corresponds to step S604 in FIG. 8.

In step S611, the switch processing unit 221 judges whether or not the received packet is a packet of the FLOGI (FLOGI packet). If the packet is a FLOGI packet, control is passed to step S612. If the packet is not an FLOGI packet, control is passed to step S615.

In step S612, the protocol processing unit 215 transforms an FLOGI packet into a FDISC packet.

In step S613, the protocol processing unit 215 outputs an FDISC packet from the transmission port 212 (Proxy port) connected to the FC switch 301 through the switch processing unit 221.

In step S614, the protocol processing unit 215 records the port number of the reception port 211 which has received the FLOGI packet in the reception port of the FLOGI process DB 216, the port number of the transmission port 212 which has transmitted the FDISC packet in the transmission port of the FLOGI process DB 216, the header information about the FLOGI packet (the source MAC address and the FC exchange ID) in the pre-transform packet header information in the FLOGI process DB 216, and the header information (FC exchange ID) of the FDISC packet in the post-transform packet header information in the FLOGI process DB 216.

As described in the processes in steps S611 through S614, when the Ethernet switch 201 receives a FLOGI packet for establishment of a connection from the FCoE device (servers 401-1, 401-2 or the storage 501-1, 501-2) connected to the Ethernet switch 201, the Ethernet switch 201 transforms the packet into an FDISC packet, and transmits the resultant packet to the FC switch 301. In this case, the Ethernet switch

201 records the information about the FC device which has performed the FLOGI in the FLOGI process DB 216.

In step S615, the packet processing unit 225 searches the FCoE destination DB 232 using the destination ID (D_ID) of the received packet as a search key.

In step S616, the packet processing unit 225 judges whether or not there is a Fabric port connected to the port of the destination ID of the received packet. In detail, when a record having the FC ID identical to the D_ID of the received packet is detected in the retrieval in step S615, the packet processing unit 225 judges that there is a Fabric port connected to the port of the destination ID of the received packet. When there is a Fabric port connected to the port of the destination ID of the received packet, control is passed to step S617. When there is no Fabric port connected to the port of the destination ID of the received packet, control is passed to step S619.

In step S617, the packet processing unit 225 instructs the packet update unit 224 to change the header of the received packet. At the instruction, the packet update unit 224 changes the header of the packet.

Described below are the details of the change of the header of the packet.

FIG. 10 illustrates a packet before and after the change according to the first embodiment.

A packet 150 includes a MAC header, an FCoE header, an FC payload, padding, and CRC.

The MAC header includes a destination MAC address, a source MAC address, VLAN, and ether type.

The destination MAC address is a MAC address of the port of the destination device to which a packet is next transmitted.

The source MAC address is a MAC address of the port of the device which has transmitted the packet immediately before.

The VLAN is an option of the FCoE packet.

The ether type refers to the type of packet.

The FC payload includes an destination ID (D_ID) and a source ID (S_ID).

The destination ID is the FC ID of the destination port of a packet.

The source ID is an FC ID of the port of the source of the packet.

In the first embodiment, the destination MAC address of the packet 150-1 before a change (that is, a packet received by the switch 201) describes the MAC address of the FC switch 301, and the source MAC address describes the MAC address of the source end node (any of servers 401-1, 401-2 and storage 501-1, 501-2).

The packet update unit 224 writes the destination MAC address of the packet 150-1 to the source MAC address of the packet 150-1. The packet update unit 224 also writes the MAC address of the port corresponding to the destination ID of the packet 150-1 to the destination MAC address of the packet 150-1. The packet update unit 224 also changes the CRC depending on the change of the header.

By the process above, the MAC address of the destination end node is described in the destination MAC address of the changed packet 150-2 (that is, the packet output by the switch 201), and the MAC address of the FC switch 301 is described in the source MAC address of the changed packet 150-2.

The description below is given with reference back to FIG. 9.

In step S618, the relay processing unit 226 transmits a packet whose header has been changed from the Fabric port connected to the port of the destination ID. In detail, the

relay processing unit **226** transmits a packet whose header has been changed from the transmission port **212** indicated by the port number included in the record detected in step **S615**.

In step **S619**, the relay processing unit **226** transmits a packet from the Proxy port in the transmission port **212**.

Described below is a concrete example of the header of a packet and the path of a packet when the packet is transmitted between FCoE devices.

FIG. **11** illustrates a communication between FCoE devices.

FIG. **11** illustrates the case in which a packet is transmitted from the server **401-1** to the storage **501-2**.

Assume that the MAC address of the server **401-1** is MAC_A. Also assume that the MAC address of the storage **501-2** is MAC_B, the FC ID of the storage **501-2** is ID_B, the MAC address of the FC switch **301** is MAC_X.

The destination MAC address of the packet **160-1** output from the server **401-1** is MAC_X, and the source MAC address is MAC_A. The destination ID of the packet **160-1** is ID_B.

A change of a header described in step **S617** is made to the packet **160-1** input to the Ethernet switch **201**, and the header-changed packet **160-2** is output to the storage **501-2**.

The destination MAC address of the header-changed packet **160-2** is MAC_B, and the source MAC address of the header-changed packet **160-2** is MAC_X. In addition, the destination ID of the packet **160-2** is unchanged as ID_B.

FIG. **12** is a detailed flowchart of the Proxy port reception process according to the first embodiment.

FIG. **12** corresponds to step **S605** in FIG. **8**.

In step **S621**, the switch processing unit **221** judges whether the received packet is the FDISC ACC or the FDISC REJECT(RJT) addressed to the Ethernet switch **201**. If the received packet is the FDISC ACC or the FDISC RJT addressed to the Ethernet switch **201**, control is passed to step **S622**. If the received packet is not the FDISC ACC or the FDISC RJT addressed to the Ethernet switch **201**, control is passed to step **S630**.

In step **S622**, the protocol processing unit **215** searches the FLOGI process DB **216** using the FC exchange ID of the packet as a search key. In detail, the protocol processing unit **215** checks whether or not the FC exchange ID of the packet matches the FC exchange ID described in the post-transform packet header information of the FLOGI process DB **216**. That is, if the received packet is the FDISC ACC (ACCEPT of FDISC) or the FDISC RJT (REJECT) addressed to the protocol processing unit **215**, then the packet is a reply to the packet transmitted after transforming the FLOGI to the FDISC. Therefore, it is checked whether or not there is a record of the FLOGI processing.

In step **S623**, when the protocol processing unit **215** detects the record of the FLOGI processing (that is, if a record describing the FC exchange ID which is identical to the FC exchange ID of the packet is detected), control is passed to step **S624**. If it is not detected, control is passed to step **S629**.

In step **S624**, the protocol processing unit **215** checks whether the packet is the FDISC ACC or the FDISC RJT. If the packet is the FDISC ACC, control is passed to step **S625**. If the packet is FDISC, control is passed to step **S627**.

In step **S625**, the protocol processing unit **215** transforms the FDISC ACC into FLOGI ACC, and outputs the FLOGI ACC from the Fabric port connected to the source port of the FLOGI. The Fabric port connected to the source port of the FLOGI is the transmission port **212** corresponding to the

port number described in the reception port of the record detected from the FLOGI process DB **216** in the search in step **S622**.

In step **S626**, the protocol processing unit **215** instructs the packet processing unit **225** to record the source address of the FLOGI (MAC address and the FC ID) and the information (port number) about the port connected to the source. The packet processing unit **225** records the source address (MAC address and FC ID) of the FLOGI and the information about the port (port number) connected to the source in the FCoE destination DB **232**.

In step **S627**, the protocol processing unit **215** transforms the FDISC RJT into the FLOGI RJT, and outputs the FLOGI RJT from the Fabric port connected to the source port of the FLOGI.

In step **S628**, the protocol processing unit **215** deletes the record (that is, the record detected in step **S622**) corresponding to the FDISC ACC or the FDISC RJT from the FLOGI process DB **216**.

In step **S629**, the protocol processing unit **215** performs error handling.

In step **S630**, the switch processing unit **221** outputs a packet from the Fabric port connected to the port of the destination ID.

Described next is the method of enhancing the security in the first embodiment.

The port login (PLOGI) command in the FCoE or FC is to perform a login of a port between a server and storage etc. After the completion of the PLOGI, data may be transferred between ports. The process described below is to monitor the PLOGI, relay the shortcut only between the ports for which the PLOGI has been established, and enhance the security by discarding other packets.

FIG. **13** is a flowchart of the first security check process according to the first embodiment.

The first security check process in steps **S631** through **S634** is performed between steps **S616** and **S617** of the Fabric port reception process in FIG. **9**.

In step **S631**, the switch processing unit **221** judges whether or not the packet is the PLOGI ACC. If the packet is the PLOGI ACC, control is passed to step **S632**. If the packet is not the PLOGI ACC, control is passed to step **S633**.

In step **S632**, the protocol processing unit **215** instructs the packet processing unit **225** to record the information (that is, the FC IDs of two ports) about the pair of the FC IDs of the ports which have performed the PLOGI. The packet processing unit **225** records the pair information about the FC ID of the ports which have performed the PLOGI. Thus, the FCoE security DB **233** describes the pair information about the ports which have become able to communicate (whose connection has been established) with each other.

In step **S633**, the packet processing unit **225** judges whether or not the packet is the PLOGI RJT. If the packet is the PLOGI RJT, control is passed to step **S617**. If the packet is not the PLOGI RJT, control is passed to step **S634**.

In step **S634**, the packet processing unit **225** checks whether or not the destination ID and the source ID of the packet are described in the FCoE security DB **233**. If the destination ID and the source ID of the packet are not described in the FCoE security DB **233**, then the switch processing unit **221** discards the packet. In step **S634**, the packet processing unit **225** checks the FCoE security DB **233**, thereby judging whether or not the connection between the source and the destination has been established. A communication is allowed between the ports where the

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connection has been established. The packet is discarded between the ports where the connection has not been established.

In the process above, security information is acquired by monitoring the PLOGI processing. Described next is the case in which security information is acquired from the Zone database of the FC switch.

FIG. 14 is a flowchart of the second security check process according to the first embodiment.

The second security check process in steps S641 through S646 in FIG. 14 is performed between steps S616 and S617 in the Fabric port reception process in FIG. 9.

In step S641, the switch processing unit 221 judges whether or not the packet is the PLOGI ACC. If the packet is the PLOGI ACC, control is passed to step S642. If the packet is not the PLOGI ACC, control is passed to step S645.

In step S642, the protocol processing unit 215 acquires the pair information about the ports which have performed the PLOGI from the Zone database of the FC switch 301. The Zone database describes the pair information about the ports for which a communication is permitted, and the worldwide name (WWN).

In step S643, the protocol processing unit 215 judges whether or not the pair of ports which have performed the PLOGI is permitted to perform a communication according to the information acquired from the Zone database. If a communication is permitted, control is passed to step S644. If a communication is not permitted, control is passed to step S617.

In step S644, the protocol processing unit 215 instructs the packet processing unit 225 to record the pair information of the FC IDs of the ports which have performed the PLOGI. The packet processing unit 225 records the pair information about the FC IDs of the ports which have performed the PLOGI in the FCoE security DB 233. Thus, the FCoE security DB 233 describes the pair information about the ports for which a communication is permitted and a connection has been established.

In step S645, the packet processing unit 225 judges whether or not the packet is the PLOGI RJD. If the packet is the PLOGI RJD, control is passed to step S617. If the packet is not the PLOGI RJD, control is passed to step S646.

In step S646, the packet processing unit 225 checks whether or not the destination ID and the source ID of the packet are described in the FCoE security DB 233. If the destination ID and the source ID of the packet are not described in the FCoE security DB 233, then the switch processing unit 221 discards the packet.

According to the Ethernet switch in the first embodiment, a packet may be directly transmitted to a destination device without the relay of the FC switch, thereby reducing the communication latency. Furthermore, the bottleneck of the communication between the Ethernet switch and the FC switch may be avoided.

Second Embodiment

Described next is the embodiment of using the FC switch instead of the Ethernet switch.

FIG. 15 illustrates a configuration of the system according to the second embodiment.

A system 1101 includes an FC switch 1201, an FC switch 1301, a server 1401-*i* (*i*=1 to 4), and storage 1501-*i*.

The FC switch 1201 performs processes of routing and transforming a packet etc.

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The FC switch 1201 has a gateway using the N_Port ID Virtualization (NPIV), and is connected to the FC switch 1301 using the NPIV.

The NPIV refers to the technology of virtualizing the ID of an N_Port to allow one physical port (N_Port) to have a plurality of port names and fabric addresses.

The FC switch 1201 presents the FC switch 1301 with a plurality of devices as if they were one device using the NPIV.

The FC switch 1201 is connected to the FC switch 1301, servers 1401-1 and 1401-2, and storage 1501-1 and 1501-2.

The FC switch 1201 is connected to the FC switch 1301, the servers 1401-1 and 1401-2, and the storage 1501-1 and 1501-2 through an optical fiber cable to communicate with the FC switch 1301, the servers 1401-1 and 1401-2, and the storage 1501-1 and 1501-2.

The FC switch 1301 is connected to the FC switch 1201, servers 1401-3 and 1401-4, and storage 1501-3 and 1501-4.

The FC switch 1301 is connected to the FC switch 1201, the servers 1401-3 and 1401-4, and the storage 1501-3 and 1501-4 through an optical fiber cable to communicate with the FC switch 1201, the servers 1401-3 and 1401-4, and the storage 1501-3 and 1501-4.

The FC switch 1301, the servers 1401-3 and 1401-4, and storage 1501-3 and 1501-4 configure an FC-SAN.

The server 1401 is an information processing device which performs various processes.

The servers 1401-1 and 1401-2 have an FC interface, and communicate with the FC switch 1201 using the FC. The servers 1401-1 and 1401-2 have ports for use in connecting to the FC switch 1201, and each port is assigned a unique Fibre Channel ID.

The servers 1401-3 and 1401-4 have functions similar to those of the servers 1401-1 and 1401-2. Therefore, the explanation of the functions is omitted here.

The storage 1501 is a device which stores data. The storage 1501 is, for example, a disk array device having a plurality of hard disk drives.

The storage 1501-1 and 1501-2 have an FC interface, and communicate with the FC switch 1201 using the FC. The servers 1501-1 and 1501-2 have ports for use in connecting to the FC switch 1201, and each port is assigned a unique Fibre Channel ID.

The storages 1501-3 and 1501-4 have functions similar to those of the storages 1501-1 and 1501-2. Therefore, the explanation of the functions is omitted here.

FIG. 16 illustrates a configuration of the FC switch according to the second embodiment.

The FC switch 1201 includes a reception port 1211-*j* (*j*=1~*n* (*n* is an integer)), a transmission port 1212-*j*, a protocol processing unit 1215, and a switch processing unit 1221.

The reception port 1211 is connected to the FC switch 1301, the servers 1401-1 and 1401-2, or the storage 1501-1 and 1501-2, and receives a packet.

The transmission port 1212 is connected to the FC switch 1301, the servers 1401-1 and 1401-2, or the storage 1501-1 and 1501-2, and transmits a packet.

The reception port 1211-*j* and the transmission port 1212-*j* configure a set of ports, and the reception port 1211-*j* and the transmission port 1212-*j* are assigned the same port numbers.

In the present embodiment, the reception port 1211 and the transmission port 1212 which is connected to the FC switch 1301 is called a Proxy port.

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Similarly, the reception port **1211** and the transmission port **1212** which is connected to the servers **1401-1** and **1401-2** or the storage **1501-1** and **1501-2** is called a Fabric port.

The protocol processing unit **1215** performs processes of establishing a connection, monitoring a protocol, instructing the switch processing unit **1221**, etc.

The protocol processing unit **1215** includes a FLOGI process database (DB) **1216**.

The protocol processing unit **1215** is realized by, for example, the central processing unit (CPU) (not illustrated in the attached drawings) which reads and executes the software stored in the memory (not illustrated in the attached drawings) in the FC switch **1201**. The protocol processing unit **1215** may also be realized by, for example, a hardware circuit, a processor, etc.

The FLOGI process DB **1216** is a record of the process of the FLOGI which is one of the protocols (FCoE initialization protocols) for establishment of a connection in the FCoE which is executed by the FC switch **1201**.

FIG. **17** is an example of the FLOGI process DB.

The FLOGI process DB **1216** includes items of a reception port, a transmission port, pre-transform packet header information, and post-transform packet header information. The reception port, the transmission port, the pre-transform packet header information, and the post-transform packet header information are associated with one another and stored in the FLOGI process DB **1216**.

The reception port is an identifier indicating a port which has received a packet. The reception port describes, for example, a port number of the reception port **1211** which has received a packet.

The transmission port is an identifier indicating a port which has transmitted a packet. The transmission port describes, for example, a port number of the transmission port **1212** which has transmitted a packet.

The pre-transform packet header information is the information about a header of a packet before transform (FLOGI). The pre-transform packet header information includes an FC exchange ID.

The source MAC address is a MAC address of the device which has transmitted the packet of the FLOGI.

The post-transform packet header information is the information about a header of a packet after transform (FDISC). The post-transform packet header information includes an FC exchange ID.

The switch processing unit **1221** includes a multiplexer **1222**, a packet buffer **1223**, a packet processing unit **1225**, a relay processing unit **1226**, a demultiplexer **1227**, and a storage unit **1228**.

The switch processing unit **1221** is realized by, for example, a hardware circuit, a processor, etc.

The multiplexer **1222** outputs to the packet buffer **1223** a packet input from the protocol processing unit **1215** and the reception port **1211**. From the packet output from the multiplexer **1222**, the header information extraction unit (not illustrated in the attached drawings) extracts header information, and inputs the information to the packet processing unit **1225**.

The packet buffer **1223** is a buffer which temporarily stores a received packet. The packet buffer **1223** outputs a stored packet to the demultiplexer **1227**.

The packet processing unit **1225** determines the process of a packet based on the header information, a transfer DB **1234**, and an FC security DB **1235**. The packet processing unit **1225** performs a write and a read to and from the transfer DB **1234** and the FC security DB **1235**.

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The relay processing unit **1226** outputs to the demultiplexer **1227** a control signal indicating the destination of the output packet based on the transfer DB **1234**.

The demultiplexer **1227** outputs a packet to the transmission port **1212** or the protocol processing unit **1215** according to the control signal from the relay processing unit **1226**.

The storage unit **1228** is a device which stores data. The storage unit **1228** is, for example, RAM (random access memory). The storage unit **1228** stores the FC security DB **1235** and the transfer DB **1234**.

The FC security DB **1235** is the information indicating a set of ports capable of performing a communication.

The transfer DB **1234** is the information indicating the connection between the port of the external device for connection to the FC switch **1201** and the port of the FC switch **1201**.

FIG. **18** is an example of a transfer DB.

The transfer DB **1234** includes items of an FC ID and a port number. The transfer DB **1234** describes associated FC ID and port number.

The FC ID is an identifier assigned to the port of the device to which the FC switch **1201** is connected.

The port number indicates the transmission port **1212**.

FIG. **19** is a flowchart of the packet process of an FC switch according to the second embodiment.

In step **S1601**, the protocol processing unit **1215** and the switch processing unit **1221** performs a fabric login (FLOGI) to the FC switch **1301**.

In step **S1602**, the switch processing unit **1221** waits for the reception of a packet. When the switch processing unit **1221** receives a packet, control is passed to step **S1603**.

In step **S1603**, the protocol processing unit **1215** and the switch processing unit **1221** judge whether or not the received packet has been received by the Proxy port. If the received packet has been received by the Proxy port (that is, the packet has been received from the FC switch **1301**), control is passed to step **S1605**. If the received packet has not been received by the Proxy port (that is, the packet has been received from the servers **1401-1** and **1401-2** of the storage **1501-1** and **1501-2**), then control is passed to step **S1604**.

In step **S1604**, the FC switch **1201** performs the Fabric port reception process. The Fabric port reception process is described later in detail.

In step **S1605**, the FC switch **1201** performs the Proxy port reception process. The Proxy port reception process is described later in detail.

FIG. **20** is a detailed flowchart of the Fabric port reception process according to the second embodiment.

FIG. **20** corresponds to step **S1604** in FIG. **19**.

In step **S1611**, the switch processing unit **1221** judges whether or not the received packet is a packet of the FLOGI (FLOGI packet). If the packet is a FLOGI packet, control is passed to step **S1612**. If the packet is not a FLOGI packet, control is passed to step **S1615**.

In step **S1612**, the protocol processing unit **1215** transforms the FLOGI packet into a packet of the fabric discovery (FDISC) (FDISC packet).

In step **S1613**, the protocol processing unit **1215** outputs a FDISC packet from the transmission port **1212** (Proxy port) connected to the FC switch **1301** through the switch processing unit **1221**.

In step **S1614**, the protocol processing unit **1215** records the port number of the reception port **1211** which has received the FLOGI packet in the reception port of the FLOGI process DB **1216**, the port number of the transmission port **1212** which has transmitted the FDISC packet in

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the transmission port of the FLOGI process DB **1216**, the header information about the FLOGI packet (FC exchange ID) in the pre-transform packet header information in the FLOGI process DB **1216**, and the header information (FC exchange ID) about the FDISC packet in the post-transform packet header information in the FLOGI process DB **1216**.

In step **S1615**, the packet processing unit **1225** searches the transfer DB **1234** using the destination ID (D_ID) of the received packet as a search key.

In step **S1616**, the packet processing unit **1225** judges whether or not any Fabric port is connected to the port of the destination ID of the received packet. In detail, the packet processing unit **1225** judges that there is a Fabric port connected to the port of the destination ID of the received packet when a record having the FC ID that matches the D_ID of the packet received from the transfer DB **1234** is detected. When any Fabric port is connected to the port of the destination ID of the received packet, control is passed to step **S1618**. When there is no Fabric port connected to the port of the destination ID of the received packet, control is passed to step **S1619**.

In step **S1618**, the relay processing unit **1226** transmits a packet from the Fabric port connected to the port of the destination ID. In detail, the relay processing unit **1226** transmits a packet from the transmission port **1212** indicated by the port number included in the record detected in step **S1615**.

In step **S1619**, the relay processing unit **1226** transmits a packet from the Proxy port in the transmission port **1212**.

Described below is a concrete example of the path of a packet when the packet is transmitted between the FC devices connected through the FC switch **1201**.

FIG. **21** illustrates the communication between the FC devices according to the second embodiment.

FIG. **21** illustrates the case in which a packet is transmitted from the server **1401-1** to storage **1501-2**.

Assume that FC ID of the server **1401-1** is ID_A, and the FC ID of the storage **1501-2** is ID_B.

The server **1401-1** transmits a packet **1160-1** addressed to the storage **1501-2** to the FC switch **1201**.

The destination ID of the packet **1160-1** output from the server **1401-1** is ID_B, and the source ID is ID_A.

A destination check is made on the packet **1160-1** input to the FC switch **1201**, and the storage **1501-2** is judged that it is connected to the Fabric port of the FC switch **1201**.

The FC switch **1201** transmits a packet **1160-2** to the storage **1501-2**. The contents of the packet **1160-1** are identical to the contents of the packet **1160-2**. That is, the header of the packet **1160-2** has not been changed, and the destination ID is ID_B, and the source ID is ID_A like the packet **1160-1**.

Thus, the packet output from the server **1401-1** reaches the storage **1501-2** without passing (shortcut) the FC switch **1301**.

FIG. **22** is a detailed flowchart of the Proxy port reception process according to the second embodiment.

FIG. **22** corresponds to step **S1605**.

In step **S1621**, the switch processing unit **1221** judges whether the received packet is a FDISC ACC or a FDISC RJT addressed to the FC switch **1201**. If the received packet is a FDISC ACC or a FDISC RJT addressed to the FC switch **1201**, control is passed to step **S1622**. If the received packet is not the FDISC ACC or the FDISC RJT addressed to the FC switch **1201**, control is passed to step **S1630**.

In step **S1622**, the protocol processing unit **1215** searches the FLOGI process DB **1216** using the FC exchange ID of the packet as a search key. In detail, the protocol processing

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unit **1215** checks whether or not the FC exchange ID of the packet matches the FC exchange ID described in the post-transform packet header information in the FLOGI process DB **1216**. That is, if the received packet is the FDISC ACC (ACCEPT of FDISC) or the FDISC RJT (REJECT) addressed to the FC switch **1201**, the packet is a reply to the packet transmitted after transform from the FLOGI to the FDISC. Therefore, the check is being made as to whether or not there is a record of a corresponding FLOGI process.

In step **S1623**, when the protocol processing unit **1215** detects the record of a corresponding FLOGI process (that is, when a record describing the FC exchange ID that matches the FC exchange ID of the packet is detected), control is passed to step **S1624**. If the record is not detected, control is passed to step **S1629**.

In step **S1624**, the protocol processing unit **1215** checks whether the packet is the FDISC ACC or the FDISC RJT. If the packet is the FDISC ACC, control is passed to step **S1625**. If the packet is the FDISC RJT, control is passed to step **S1627**.

In step **S1625**, the protocol processing unit **1215** transforms the FDISC ACC into the FLOGI ACC, and outputs the FLOGI ACC from the Fabric port connected to the source port of the FLOGI. The Fabric port connected to the source port of the FLOGI is the transmission port **1212** corresponding to the port number described in the reception port of the record detected from the FLOGI process DB **1216** in the search in step **S1622**.

In step **S1626**, the protocol processing unit **1215** instructs the packet processing unit **1225** to record the source address (FC ID) of the FLOGI and the information (port number) about the port connected to the source. The packet processing unit **1225** records in the transfer DB **1234** the source address (FC ID) of the FLOGI and the information (port number) about the port connected to the source.

In step **S1627**, the protocol processing unit **1215** transforms the FDISC RJT into the FLOGI RJT, and outputs the FLOGI RJT from the Fabric port connected to the source device of the FLOGI.

In step **S1628**, the protocol processing unit **1215** deletes the record corresponding to the FDISC ACC or the FDISC RJT (that is, the record detected in step **S1622**) from the FLOGI process DB **1216**.

In step **S1629**, the protocol processing unit **1215** performs the error handling.

In step **S1630**, the switch processing unit **1221** outputs the packet from the Fabric port connected to the port of the destination ID.

According to the FC switch in the second embodiment, a packet may be directly transmitted to a destination device without the relay of the external FC switch, thereby reducing the communication latency. Furthermore, the bottleneck of the communication between the FC switches may be avoided.

All examples and conditional language provided herein are intended for pedagogical purposes of aiding the reader in understanding the invention and the concepts contributed by the inventor to further the art, and are to be construed as limitations to such specifically recited examples and conditions, nor does the organization of such examples in the specification relate to a showing of the superiority and inferiority of the invention. Although one or more embodiments of the present invention have been described in detail, it should be understood that the various changes, substitutions, and alterations could be made hereto without departing from the spirit and scope of the invention.

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What is claimed is:

1. An Ethernet switch which is connected to a plurality of external devices using an encapsulating I/O protocol over Ethernet, and is connected to an I/O protocol switch using N_Port ID virtualization, the Ethernet switch comprising:

a first port which is connected to a first external device;
a second port which is connected to a second external device;

a third port which is connected to the I/O protocol switch;
a storage unit which stores destination information describing an external device whose connection is established in the encapsulating I/O protocol over Ethernet in the plurality of external devices; and

a processor, wherein:

when the processor receives a packet, from the first port, that is addressed from the first external device to the second external device in the external devices and for which the I/O protocol switch has been set as a next destination device, the processor checks whether or not the destination information describes the second external device; and

when the second external device is described in the destination information, the processor transmits the packet from the second port to the second external device.

2. The Ethernet switch according to claim 1, wherein when the processor transmits the packet to the second external device, the processor changes a destination media access control (MAC) address of the packet into a MAC address of the second external device, and changes a source MAC address of the packet into a MAC address of the I/O protocol switch.

3. The Ethernet switch according to claim 1, wherein the processor monitors a protocol which establishes a connection between the plurality of external devices in the encapsulating I/O protocol over Ethernet, and describes in the destination information an external device whose connection is established when the connection is established.

4. The Ethernet switch according to claim 1, wherein the processor describes in security information the first external device and the second external device when a port login is processed between the first external device and the second external device, and judges according to the security information whether or not the packet may be transmitted to the second external device.

5. The Ethernet switch according to claim 1, wherein: the I/O protocol switch includes a zone database describing whether or not a communication in a set of external devices is allowed;

the processor

acquires information about a set of the first external device and the second external device from the zone database of the I/O protocol switch when port login processing is performed between the first external device and the second external device;

judges according to the acquired information as to whether or not a communication between the first external device and the second external device is allowed;

describes in security information the set of the first external device and the second external device when the communication between the first external device and the second external device is allowed; and

judges according to the security information whether or not the packet may be transmitted to the second external device.

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6. A method of a communication performed by an Ethernet switch which is connected to a plurality of external devices using an encapsulating I/O protocol over Ethernet, and is connected to an I/O protocol switch using N_Port ID virtualization, and includes a first port which is connected to a first external device, a second port which is connected to a second external device, and a third port which is connected to the I/O protocol switch, the method comprising:

referring to destination information which describes an external device whose connection in the encapsulating I/O protocol over Ethernet is established in the plurality of external devices when a packet is received, from the first port, that is addressed from the first external device to the second external device in the plurality of external devices and for which the I/O protocol switch has been set as a next destination device;

checking whether or not the second external device is described in the destination information; and

transmitting the packet from the second port to the second external device when the second external device is described in the destination information.

7. The method according to claim 6, wherein in transmitting the packet, destination media access control (MAC) address is changed into a MAC address of the second external device, and a source MAC address of the packet is changed into a MAC address of the I/O protocol switch.

8. The method according to claim 6, further comprising: monitoring a protocol which establishes a connection of the plurality of external devices in the encapsulating I/O protocol over Ethernet; and

describing in the destination information an external device whose connection is established when the connection is established.

9. The method according to claim 6, further comprising: describing in security information the first external device and the second external device; and

judging according to the security information whether or not the packet may be transmitted to the second external device

in performing port login processing between the first external device and the second external device.

10. The method according to claim 6, wherein:

the I/O protocol switch includes a zone database describing whether or not a communication in a set of external devices may be allowed; and

the Ethernet switch

acquires information about a set of the first external device and the second external device from the zone database of the I/O protocol switch when port login processing is performed between the first external device and the second external device;

judges according to the acquired information as to whether or not a communication between the first external device and the second external device is allowed;

describes in security information the set of the first external device and the second external device when the communication between the first external device and the second external device is allowed; and

judges according to the security information whether or not the packet may be transmitted to the second external device.

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